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Methodological report

Development of the land account and valuation of ecosystem services regarding grassland ecosystem services

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1. Overview of the work done and the introduction to the structure of the report

Current project was a accomplishment as during quite a short time (one year) the explicit ecosystem unit map was created, ecosystem extent opening account by owners sector and activity categories was created, eight ecosystem services were selected and monetary valuations were tried out regarding the grasslands in Estonia. In addition, on the basis of ecosystem services the experimental supply and use tables were created. One ecosystem service, namely nature education ecosystem service, was analysed in depth.

This project was the first attempt to build ecosystems account in Statistics Estonia. The grant work was carried out as two connected tasks. Two steps taken by Statistics Estonia in applying UN SEEA EEA principles for the valuation of ecosystem services were:

1. Compilation of land accounts which are relevant for ecosystem extent account and handling of the classification issues (chapter 2)
2. Valuation of grassland ecosystem services, compilation of the supply and use tables and the analysis of the results (chapters 3-7)

The work was planned and carried out in cooperation with other activities on the subject currently taking place in Estonia.

The effort for compilation the land accounts relevant for ecosystem services accounts started with the compilation of GIS based land accounts (the opening extent account). The explicit map of ecosystems in Estonia has never been produced before or at least in case covering whole Estonia, so as a result of the current work a spatially explicit map of ecosystem unit map for Estonia was produced (chapter 2.3). In addition, the idea that cadastral parcels would facilitate the ecosystems linkages to economic units/activities was chosen and tested. The link to the economic and institutional dimension was created and the breakdown by institutional activities was added as a separate layer to the opening extent account (chapter 2.4). In the future the developed extent account could function as a basis for the development of ecosystem services accounts for other types of ecosystems.

At the beginning of the project, there was no spatial Estonian territory wide ecosystem type classification in use, which would cover all ecosystems. Creating spatially explicit ecosystem maps asked for the aggregation classes in order to summarize the results over the ecosystem types in a comparable manner (chapter 2.5.1.). Classifications were analysed and discussed with experts. It was decided to aggregate the Estonia's 143 different ecosystem units derived from the final dataset (which has a mix of different habitats, land-use and land cover classes) to classification types very close to LULUCF as the latter is the classification which has been territory wide used for the yearly reporting for greenhouse gases. So the broadest level of the ecosystems classification represents closely LULUCF classification.

Relevant international land and ecosystem classifications were analysed and investigated in order to link our national ecosystem classes to existing classifications (chapter 2.5.3). Also conversion to EUNIS habitat classification was carried out (chapter 2.5.2).

Regarding the valuation of ecosystem services and compilation of ecosystem services account, the focus was set on one of the heterogeneous ecosystem type in Estonia "grasslands" including both semi-natural and cultivated grassland ecosystems. Concerning the selection of the services and methods subject for the valuation of ecosystem services and compilation of ecosystem services account, stakeholders were consulted. Recent and earlier works regarding Estonian ecosystems and grassland ecosystem services accounting were studied and an overview was compiled (chapter 3.1). Biophysical assessment of ecosystem services has also started in 2019 under the responsibility of Estonian Environmental agency but the results of this work are not yet in the stage to provide us the input to the current grant work done by Statistics Estonia on the monetary assessment of ecosystem services but the activities of both organisations are coordinated.

Expert consultations, a seminar and different meetings involving interested parties, experts, ELME [1] team (responsible for abovementioned wide scale biophysical modelling of ecosystem services) and Estonian MAES (Mapping and Assessment of Ecosystem Services) team were already held at the beginning of the project in order to determine which ecosystem services can and should be evaluated and which valuation methods could be used (chapter 3.2). Simultaneously, the experts involved in monetary valuations of various ecosystem services in Estonia but also the experts who are more advanced in the field of ecosystem accounting (Statistics Netherlands and UK DEFRA) were consulted for the development of the methodology. In order to make the best use of existing experience of establishing similar accounts elsewhere and applying relevant methodological approaches, study visit to Statistics Netherlands was carried out at the beginning of the project (ANNEX 1). During the study visit work done by both sides was presented and possible future plans were discussed. An expert from UK was also consulted on the selection of the ecosystem services to be assessed and methods for valuation.

The selection of the ecosystem services to be assessed was based on the efforts in Estonia so far[2], namely the developed “The roadmap for mapping and evaluating ecosystems services”. Pilot case studies carried out in Estonia on grassland ecosystems were analysed as well. Other data sources were analysed from the viewpoint of usefulness in respect to the valuation of the ecosystem services. Overview of these relevant data sources was created. As mentioned above the valuation of ecosystem services on the example of grassland ecosystems was planned as a joint effort with ELME project currently in progress in Estonia under the umbrella of Estonian MAES, Mapping and Assessment of Ecosystem Services[3], team. But as the deadline for the ELME project has been extended to September 2020 and ELME project did not deliver the initially planned input for Statistics Estonia’s project, alternative indirect methods and approaches to carry out the valuation of the services were investigated and applied. In the next phase of the development of the ecosystem accounts, it is likely that the results of the ELME project could already be available.

Methods for monetary valuation of the grassland ecosystem services in Estonia were tested and monetary values using selected methods were derived for one selected year (chapter 3.3). Altogether 15 different services were selected for the discussions with the stakeholders and expert team. As the valuation of the services depended on the availability of data, the selection was made after analysing of the available data. It was stated in grant proposal that from ecosystem provisioning services hay, fodder,

[1] The nation wide assessment and mapping of ecosystem services, incl those of grasslands, is starting in 2018 in Estonia. The project ELME “Establishment of tools for integrating socioeconomic and climate change data into assessing and forecasting iodiversity status, and ensuring data availability” (Estonian acronym – ELME) funded by the European Union Cohesion Fund and the foundation Environmental Investments Centre takes place from 2015 to 2023. Estonian Environment Agency who is responsible for the ELME is one of the main co-operation partner of the work proposed in this grant project.

[2] Tõnu Oja, Uku Varblane, Anneli Palo, Jaanus Veemaa. „Ökosüsteemide teenuste kaardistamise ja hindamise tegevuskava“ Tartu, 2018. Project „Elurikkuse sotsiaal-majanduslikult ja kliimamuutustega seostatud keskkonnaseisundi hindamiseks, prognoosiks ja andmete kättesaadavuse tagamiseks vajalikud töövahendid“

[3] Mapping and Assessment of Ecosystem Services; https://biodiversity.europa.eu/maes

meat, wool, medicines and herbs and from regulating services carbon sequestration and habitat provision would most probably be monetized and that regarding cultural and regulating services the valuations would probably be based on the investigations made by the experts involved in the project. Eventually eight ecosystem services were chosen for monetary assessment. The description of the applied methods, data and results of valuation is presented in the chapter 3.3 of the report.

The suggestion to focus on and to carry out a more in depth research regarding nature education as an ecosystem service was given by project adviser (DEFRA, Rocky Harris). Concepts were analysed, definition of the service was agreed and valuation and integration of the nature education ecosystem service was carried out. As a result of this experimental work, the assessment of the nature education as an ecosystem service and the tested logic and methodology are described in current report. Methodology was also presented to the London Group on Environmental Accounting [4] for discussion. The discussion was followed by more in-depth discussions with the revisers of the UN SEEA EEA [5] as several of the issues which we tackled are important from the revision process as well, for example: how to find the share of the contribution of ecosystem from the total service value, which expenditures to include if basing the valuations on expenditures in some way, which indicators of condition would be relevant for assessing the continuing capacity of the ecosystem to supply nature education services, importance of the determining of the ecosystem service supplying areas both in the context of the single services macro assessments or the assessments of relative importance of a particular ecosystem and ecosystem type. We described how the accounting system can record the contribution of the ecosystem to the value of the ecosystem services and benefits. The depth of handling of these aspects varies among services. In order to maintain certain coherence among the calculated services in the developed supply and use table and summary tables of the services, we did not include the calculation results referring to the narrower concept of ecosystem contribution.

The results of contingent valuation study on valuation grasslands ecosystems services carried out in Tallinn Technical University in collaboration with current work were analysed as well as presented in parallel. The total annual willingness to pay (hereafter WTP), 18.8 million €, of Estonian adult population for ecosystem services provided by Estonian grasslands was compared with the values derived by other parallel methods and gave the results of the same scale.

If spatial dimension and defining the area which is supplying the service are not important for national level macroeconomic assessments of the total flows of ecosystem services then for analyses which are dealing with relative importance of a specific ecosystems or ecosystem types in provisioning of certain services or for the analyses which handle the spectrums of the services provided by single ecosystem types, - the spatial dimension is important. In current work we have estimated several service values at the country level and where possible made an effort to distinguish between contributions of different grassland types to the annual service values. The calculation of the provided service values per grassland types was created allocating the calculated values for certain ecosystem type (potential supply) or using the composition of the ecosystems in the provisioning area (actual supply). The ecosystem service provisioning area was handled for each service separately (chapter 3.5.1).

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[4] 25th Meeting of the London Group on Environmental Accounting 7-10 October 2019, Melbourne. https://seea.un.org/sites/seea.un.org/files/lg_article_nature_education_as_ecosystem_service_estonia_03_oct.pdf

[5] Personal communication with Carl Obst and discussions on a methodological seminar November 27-28, 2019 (Annex 2) with Sjoerd Schenau and Rocky Harris.

Derived accounts could in principle aim for the comprehensive comparison of the contributions of single ecosystems and their groups in provision of ecosystem services. Monetary values for a set of eight selected ecosystem service were estimated for Estonian grasslands. Comparing cultivated and semi-natural grassland ecosystem services, it can be argued that they both play an important role in providing ecosystem services, but in different ways. The comparison of the service values based on current selection of the eight services and based on described assumptions show that semi-natural and cultivated grasslands differ in the service provisioning capacity: cultivated grasslands contribute 28.8 million € and semi-natural grasslands contribute 13.7 million €.

The high total monetary ecosystem service value of cultivated grasslands is most influenced by the input of fodder provisioning service, but also pollination and hunting ecosystem services have a significant contribution to the total service value of cultivated grasslands.

Semi-natural grasslands contributed altogether 65% of the ecosystem service value for medicinal herbs, 100% of the ecosystem service value for the provisioning of hay for bioenergy, 84% of service value for nature education and 58% of the value for the recreation ecosystem service.

From semi-natural grasslands, which are situated in Natura 2000 areas, biggest contributors of estimated (valued in monetary terms) eight ecosystem services are Northern boreal alluvial meadows (6450) which are distinguished by their high contribution of the fodder production ecosystem service and Nordic alvar and Precambrian calcareous flat rocks (6280) which could be distinguished by their higher provision of the pollination service. Boreal Baltic coastal meadows (1630) are distinguished by their general higher contribution of providing ecosystem services. Higher contribution in absolute terms is generally also related to the higher area of these ecosystems.

Calculated average hectare-based values of eight selected ecosystem services provide a better comparison of cultivated and semi-natural grasslands as these are more independent of the total area of different ecosystem types (chapter 3.5.2). Summing up the average ecosystem service values per ecosystem types was demonstrated for grasslands and eight services selected. In respect to the specific grasslands ecosystems it should be noted that cultivated grasslands provide higher total hectare values (113-122 € per ha) due to general higher fodder production. Semi-natural grasslands feature lower per hectare total values (in average 57 € per ha, ranging from 24 € per ha to 71 € per ha). Fixed coastal dunes with herbaceous vegetation ("grey dunes"; 2130) contribute the highest values per total of the whole semi-natural grasslands group 76 € per ha due to the higher provision of recreational service. Semi-natural dry grasslands and scrubland facies on calcareous substrates (6210) feature the second highest per hectare value which was mostly influenced by the ability to provide simultaneously the higher fodder production, pollination service and recreation service. Third highest are the Fennoscandian wooded pastures (9070) also due to featuring the higher fodder production and pollination service.

However it should be kept in mind that eight services were valued and currently several relevant regulative services are not included in the calculations yet (like flood protection, water filtration)

One of the goals of this project was to compile a supply and use table for the calculated ecosystem service values. The results of the selected services valuations (8 services) regarding the grasslands were presented in a format of the ecosystem services supply and use table (according to table 5.1 from

Technical Recommendations…[6]) by grasslands was compiled for the selected year. Supplies are distributed between ecosystem types and by ecosystem service and the uses are distributed by institutional sector and by ecosystem service (chapter 4).

Another related goal was to make an attempt to integrate the ecosystem service values with national accounts supply and use tables and analyse these in sense of SNA and non-SNA (chapter 4) flows. As an example the integration of nature education ecosystem service was made. Results of all considered ecosystem service values show that some of the values calculated during the project were already included in national accounts but not considered as ecosystem services (as ecosystem is not traditionally separate institutional sector that supplies services). Calculating the ecosystem service values gives initial ideas on the opportunity to add extra dimension to national accounts tables and possibility to see how ecosystems contribution could be presented. The treatment of grassland related ecosystem services flows in national accounts tables and the ecosystem services flows covered in SNA and not were discussed and allocated in collaboration with experts from the more experienced National Statistical Organisation (NSI), also JRC respective expert [7] were consulted. The nature education as ecosystem service was analysed also regarding the separation of the ecosystem contribution in provisioning of the service (chapter 4).

Seminar was organized in second half of the project (November 27-28, 2019) to discuss the methods and summarize the results ("Development of the ecosystem extent account and valuation of grassland ecosystem services") in Statistics Estonia (ANNEX 2). Seminar brought together both the experts from Estonia and abroad and also local stakeholders and partners. Statistics Estonia gave an overview of the work done and the update of the progress so far in Estonia on ecosystem accounts, compiled extent account and valued ecosystem services, approaches, methods and results of the work in 2019. Assembling of the ecosystem services in the framework of SNA and supply and use tables and use of the accounts was discussed. Representatives of Environmental Ministry and ELME discussed the efforts to set the ecosystem accounts into the wider context of policy, for example nature conservation action plan. The further co-ordination of the future tasks on a next more mature phases of the development of the ecosystem extent account was acknowledged by participants. The applied methods were reviewed both by the Estonian experts and the experts of more developed statistical organisations, involved in the project. Calculations for the valuation of provisioning (fodder, medical herbs, raw material for bioenergy, game), regulating (pollination, climate regulation) and cultural (recreation, nature education) service values which have been done in parallel with various methods were analysed in expert group, chosen methods were discussed and were mainly approved. It was noted by the project experts that the selection of best methodologies could be still made in later stages and some of the results could still be treated as experimental. It was acknowledged that clear improvements are difficult to achieve with current available data and that there might be a room for improvements in the follow-up project. Initial ideas on the applicability of the ecosystem accounts in Estonia were discussed (chapter 5).

[6] UN (2017) SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft. New York, USA.
https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

[7] Personal communication with Alessandra la Notte, JRC

Current work was an experimental work, so there have been lot of issues we have gone through and we have had a lot of discussions. Chapter 7) outlines several of the issues encountered and the references to the respective chapters. In general the issues we tackled could be divided to the more general ones (conceptual issues, measurement boundaries, use and the applicability and the meaning of the developed accounts). Secondly there are problems which are rather specific for the separate services: availability of the data, selection of the methods for monetary valuation, agreement on the methods (chapter 7).

Final results of the current project will feed as input to the future work in this area. Widening the scope to other ecosystem types was suggested. The continuing of the started work in Statistics Estonia especially on valuation of cultural services was suggested also by the UN SEEA EEA revisers.[8] It has been considered a challenging area and Statistics Estonia's efforts to work through the issues that have been considered important for increasing the understanding from a statistical and accounting perspective. The definition and framing, development of the methodologies for measurement, having a consistent approach across different cultural services - potentially applying the Fish model - would be useful. Thus seeing how the Fish model[9] currently applied for nature education service can be applied also for other cultural services would be a valuable direction to go forward.

There is still quite a way to go in order to improve valuation methods, develop relevant semantics and set the valued figures in a wider context of the policy debate on conservation and maintenance of ecosystem assets and services.

Current report is supplemented by the set of the tables in MS Excel format "Data sets on the main results" which is delivered separately and it contains:

1. Opening extent account, classified according to the closest broad classes of the UNFCCC/IPCC land use classes (LULUCF) and institutional sectors, ha, 2019
2. Opening extent account, classified according to the closest broad classes of the UNFCCC/IPCC land use classes (LULUCF) and economic activities, ha, 2019
3. Opening extent account, classified according to the broad EUNIS habitat type classes, ha, 2019
4. Opening extent account, classified according to the most detailed EUNIS habitat type classes, ha, 2019
5. Estonian grassland ecosystem types by activity sectors and economic activities, ha, 2019
6. The supply of the services for grasslands ecosystems (parallel methods), thousand €, 2018
7. Supply of ecosystem services for grasslands, selected methods and total value of eight selected services, thousand €, 2018
8. Average ha values for ecosystem services (several parallel methods), € per ha, 2018
9. Experimental average hectare values of the ecosystem services (preferred method) and the sum of the services, € per ha, 2018
10. The supply and use of grassland ecosystem services (million €), 2018
11. The supply and use of nature education service (million €), 2018
12. Willingness to pay for ecosystem services provided by Estonian meadows per year, 2019

[8] Personal communication with Carl Obst, October 2019 and memeber s of the London Group.

[9] Fish, R., Church, A., Winter, M., 2016 Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. Ecosystem Services, Volume 21, Part B, 2016, Pages 208-217, ISSN 2212-0416, https://doi.org/10.1016/j.ecoser.2016.09.002

2. Compilation of ecosystem extent opening account relevant for ecosystem services accounts

2.1 Overview of the ecosystem extent account compilation

The compilation of land accounts[10]needed for ecosystem services accounts is an important part of the current grant. Land accounts relevant for ecosystem services accounts were developed as fully spatial approach - a GIS based opening extent account.

First challenge was to develop a detailed explicit map of the Estonia's ecosystems, an effort which has never been undertaken before at the scale of whole country. The idea was that developed ecosystem extent account would form a foundation for the future, when other ecosystems and services would be under the study. For the production of the map of Estonian ecosystems, the spatially informed datasets were used. Accounting basic matrix in the sense of ecosystem extent account is now in one hand integrating data of Estonia ecosystems with an additional dimension of economic and institutional units. The idea that cadastral parcels would facilitate the linkages to economic units/activities was chosen and tested on a spatially explicit map of ecosystems for Estonia by adding an owner's dimension.

Second challenge was to decide, which kind of classification system to use for mapping units. Therefore, classification system had to be selected. Existing national and international classifications for ecosystems and land use were analysed and the best options, in the sense of detail and comparability were chosen. It was decided to use for the aggregation to main ecosystem types a LULUCF classification, which differentiates between six broad classes (cropland, forest land, grassland, settlements, wetland and other). In addition, we made an effort to link the original classification to EUNIS habitat classification, which is much more detailed compared to latter.

2.2 Description of the data sources for ecosystem unit base map

At the beginning of the project, the first step was to carry out the inventory of the data potentially necessary for the compilation of ecosystem unit base map and in order to build a basis for the further development of various ecosystem services accounts in future. Carried out inventory of the land accounts data and the compilation for the basic matrixes (delineating ecosystems types by economic units) were compiled in line with guidelines given in Technical Recommendations in support of the System of Environmental-Economic Accounting 2012–Experimental Ecosystem Accounting and with UN SEEA guidelines[11]. The leading idea was to cover all the main broad ecosystems types in Estonia (e.g. agricultural land, forests, grasslands, settlements, wetlands) and use most up to date and as well detailed data as possible. The overview of data used in this project for ecosystem and land accounts are described below in Table 1 (see also table in ANNEX 3 for additional details):

[10] It should be noted that land accounts are handled here as ecosystem extent accounts.
[11] UN (2017) SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft. New York, USA.
https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

Table 1. Data sources and accompanying attributes for the data used in order of compiling ecosystem unit map. Ecosystem type refers to LULUCF classification as how we regarded the mapping units in broad class (see also additional details from table in ANNEX 3).

Data source	**Ecosystem type**	**Classification**	**Number of classes**	**Data Type**
Estonian Agricultural Registers and Information Board	Cropland/ Grassland/ Other	Original/local	8	Vector
Forest registry of Estonia	Forest land	Original/local	32	Vector
Estonian Nature Foundation	Wetland/ Forest land/ Grassland/ Other	Natura 2000 habitats	57	Vector
Semi-natural habitats	Grassland/ Wetland/ Other	Natura 2000 habitats	15	Vector
Natura 2000 habitats (Annex I habitats)	Forest land/ Grassland/ Wetland/ Other	Natura 2000 habitats	60	Vector
Estonian Semi-natural Community Conservation Association	Grassland	Natura 2000 habitats	12	Vector
Estonian Topographic Database	Cropland/ Forest land/Grassland/Wetland/Settlements/Other	Original/local	34	Vector

Data for agricultural land in Estonia was obtained from Estonian Agricultural Registers and Information Board and Estonian Topographic Database. While Agricultural Registers and Information Board have information about croplands which do receive support then information from Estonian Topographic Database gives information about croplands which are not receiving support and could be potentially be abandoned. Data for cropland from Estonian Agricultural Registers and Information Board has five classes, what we consider as cropland classes: cropland, permanent crops, short-term grassland, restored grassland and fallow land. Data for cropland from Estonian Topographic Database just gives one land cover class as arable land what we consider as cropland.

Data for forest land in Estonia was mainly obtained from Forest registry of Estonia. Around 80% of forest land is entered into registry, as the forest register contains data on forest land for which a management plan has been prepared and the management plan is not obligatory for forest owner in Estonia. This dataset uses local classification with 32 different forest types in the registry (see ANNEX 5). Additional information about forests land distribution was obtained from Natura 2000 habitats dataset (see ANNEX 5) and Estonian Nature Foundation dataset as well from Estonian Topographic Database, latter having information only about land cover, either land is forest land or something else.

Data for wetlands was mainly obtained from Estonian Fund for Nature. Additional information about wetlands was obtained from Natura 2000 habitats dataset (see ANNEX 5, Table 1) and Semi-natural habitats dataset as well Estonian Topographic Database. Altogether we had 27 different types of mapping units (we also consider inland waters as wetlands in our broad classification system) which we considered as wetlands (16 are classified as Natura 2000 habitats and 11 as classes are from Estonian Topographic Database).

All the datasets contributed to a greater or lesser extent for data of grasslands, expect Forest registry of Estonia, which only deals with forest land. Therefore, we had to deal with different classifications between different datasets as well with temporal dimension (see details below). Finally, we considered 20 mapping units as grasslands (see tables in ANNEX 3 and ANNEX 5).

Data for settlements in Estonia was only obtainable from Estonian Topographic Database. Therefore classes used in settlements class are quite broad (see table in ANNEX 5)

We regarded 13 different mapping units as settlements class. Everything else that we could not classify as either as cropland, forest land, grassland, wetland, settlement was classified as *other* class. Finally, we considered 21 mapping units as other class.

2.3 The creation of the explicit ecosystem map

2.3.1 Principles and technical solutions

The first step in developing ecosystem extent account one needs first to determine ecosystem accounting area (EAA)[12]. In this project EEA was delimited as terrestrial land of Estonia including inland waters (expect the two largest lakes: Võrtsjärv and Peipsi). Altogether EEA accounted for the area of 43 465 km^2.

In this project, the Estonian topographic database served as a basis for the creation ecosystem unit base map. We updated this basis with additional data layers where more detailed data for ecosystem units was available (see ANNEX 3). In areas where more detailed information was not available, the Estonian topographic database was only source of information which we could use. More detailed data layers are both gathered/collected for different purposes and times, which creates inconsistencies in ecosystem boundaries but also making some records outdated. Therefore it is questionable, what is the actual state/condition of these older records. For example if something was classified as agricultural land twenty years ago, it does not necessarily mean that it's agricultural land nowadays. Therefore we set in place a *decision tree* in order to deal in one hand with data novelty and in other hand with areas where overlaps occurred between more detailed data layers.

2.3.2 Data sources for ecosystem extent

We preferred and therefore prioritized data layers which were most up to date and likely more precisely mapped. Different detailed data layers were overlaid as follows:

1. Agricultural land and semi-natural habitats (support bases)

Data for agricultural land and semi-natural habitats was obtained from Estonian Agricultural Registers and Information Board. As this was generally most up to date dataset we were able to use (base year 2018), this dataset got the highest priority. In this dataset only the lands which are under support bases are actually mapped, therefore it is quite certain that this data is both precisely mapped and to some extent verified. Nevertheless, some overlaps between agricultural land and semi-natural habitats still occurred (as owner of the land can receive support from multiple sources and purposes for the same land), in these cases we treated these overlapped areas as semi-natural habitats in order to avoid double counting.

2. Forest registry of Estonia

This was the largest and most detailed dataset that we were able to use. Most of the data is within ten years' time frame but some records are even older. This dataset covers most of the forested areas in

[12] UN (2017) SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft. New York, USA.
https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

Estonia (around 80% are mapped). Nevertheless, there were overlaps within the dataset which we dealt before merging it to other datasets. In case of overlaps we randomly merged overlapped areas to neighbouring polygons within the dataset.

3. Wetlands

Data for wetlands was obtained from Estonian Fund for Nature (ELF). Similarly to forest data, most of the data is within ten years' time frame. This dataset uses Natura 2000 habitat types as classification units and often multiple classes were given for the same area (e.g. transition areas). In order to simplify the original classification, it was therefore decided to use information about the main class/type only. In case of overlaps which were also present, we randomly merged overlapped areas to neighbouring polygons within the dataset.

4. Semi-natural habitats

This dataset consist of spatial information about Estonia's semi-natural habitats which are eligible to support and it was obtained from Estonian Environment Agency. Similarly to the last two mentioned datasets, most of the data is within ten years' time frame and uses Natura 2000 habitat types (like wetlands data) as classification units. The reason we decided to use this dataset as a fourth layer was because of, although these are the areas which are designated as eligible to support, these do not actually receive support, meaning these areas are likely not being maintained. It is questionable, what is the actual condition for older records are not known. Therefore, we decided that if the area was registered in aforementioned datasets (agricultural land, forest or wetland) then the former information was used. In case of overlaps we randomly merged overlapped areas to neighbouring polygons within the dataset.

5. Natura 2000 habitats

This dataset consist spatial information about Natura 2000 habitats in Estonia (around 10% of area is covered by Natura 2000 habitats in Estonia) and it was obtained from Estonian Environment Agency. Unfortunately, most of the data is older than ten years, although this dataset does receive constant updates and corrections. Due to presence of these older records we gave this dataset a lower priority in our decision tree. In case of overlaps we randomly merged overlapped areas to neighbouring polygons within the dataset.

6. Meadows

This dataset consist spatial information about Estonia meadows and was obtained from the Estonian Semi-natural Community Conservation Association. This dataset was the oldest we used as all the records are older than ten years. Hence, this dataset consists inaccuracies and is probably outdated. Due to these reasons we gave this dataset the lowest priority in our decision tree. In case of overlaps we randomly merged overlapped areas to neighbouring polygons within the dataset.

2.3.3 Merging different data layers into one layer

We did a manual verification on the merged dataset and due to general inaccuracies in the spatial data it was decided that some settlement types: the roads, inland waters, peatlands, quarries, and private yards needed to separately overlay with merged dataset. In case of roads two different types of road data was available: 1) polygon type of data (consisting of main roads in Estonia and 2) polyline type of data (consisting of smaller roads and trails). In case of polyline data a 5 meter buffer was created around polylines to convert polyline to polygon type of data to match with other data sources.

Merging different data layers into one layer creates additional relicts/leftovers due to fact that different ecosystem unit borders do not coincide with each other. Therefore, to simplify the merged dataset, it was decided to apply "circle method". In other words, if merged dataset polygon was smaller than a circle with radii of 5 meters (area of ~0.08 ha) it was merged to neighbouring polygon based on the length of shared border with neighbour polygon. In case, where shared border lengths were equal, we used the area of the neighbouring polygons as deciding factor. After merging and simplification of different data layers and overlying with Estonian topographic database, we were able to get more detailed information for 85% of EAA. For the remaining 15% of the area, Estonian Topographic Database was the only source of information we could use.

2.3.4 Features and the applicability of the map

The final ecosystem unit base map consisted of ca. 3.8 million polygons covering 140 different mapping units (ANNEX 5). Altogether, area of 43 465 km^2 (whole EEA) was covered by ecosystem units. As expected the forest land covered most of the Estonia (55.7%) followed by cropland (19.4%) and grassland (11.4%). Other land class have the smallest share (0.2%).

It should be noted, that this was the first time in Estonia when this kind of data intensive and detailed ecosystem unit base map was assembled and in addition in a short time. Creation of the ecosystem unit base map is a crucial first step in order to develop ecosystem service account as it both gives the opportunity to study ecosystems types' distribution separately as well spatial relationships between ecosystems types. This kind of information is needed to understand the functioning of the ecosystems and to evaluate certain ecosystem services. For example to answer the question, how pollination (as ecosystem service) by potential pollinators on agricultural lands is dependent on suitable habitats availability for the pollinators, one needs to know the spatial distribution of both agricultural lands as well suitable habitats in the landscape.

Nevertheless, as it was the first attempt to create this kind of detailed ecosystem unit base map, likely some technical issues still remain, which needs to be tackled in the coming years. Possible solutions would be refining the methods for merging and simplification as well incorporating more up to date data for ecosystem units, if this kind of information will become available in the future. In fact, at the moment, it is planned to update this base map in 2020 and 2021, as some detailed datasets, for example agricultural land and semi-natural habitats which are support bases and forest registry which are both updated regularly as new data becomes available. Therefore, our proposed decision tree can also be applied in the coming years to update the ecosystem unit base map.

2.4 Classification issues for ecosystem map

The issue which classification to use for our ecosystem base map was discussed already at the beginning of the project. The discussion in choosing classification system was also held with experts in Statistics Netherlands. It was found that it would be useful to do two tier approach, one where broad level classification classes are used and another with more detailed classes, when data allows to extract more detailed information. Nevertheless, in one hand, Estonia has its own local national classification system, e.g. "Classification of habitat types of Estonian vegetation"[13] which does takes account the local habitats peculiarities in Estonia and is quite detailed, but in other hand this classification system is not used anywhere outside Estonia which for example in accounting perspective could complicate comparisons between different countries and regions. As one goal in UNSD development work in the area of ecosystems accounting is to integrate different existing classification and to test how local classification could be mixed with international ones, it was desirable to apply suitable international classification as well.

Initially, our ecosystem unit map consisted of 140 different mapping units which are the mix of different habitat types, land-use and land cover classes (see table in ANNEX 5). Of course in practical standpoint over hundred different units are not necessary and some kind of meaningful aggregations should be made. Therefore, in addition to original classification (140 mapping units) we used for the aggregation to main ecosystem types a LULUCF classification which differentiates between six broad classes (cropland, forest land, grassland, settlements, wetland and other). In addition, we made an effort to link the original classification to EUNIS habitat classification, which is much more detailed compared to latter, as well (see details below).

2.4.1 Aggregation to main ecosystem types

Up to present there is no Estonian level ecosystem type classification in use. Creating spatially explicit maps asks for the broader aggregation classes in order to summarize and analyse the results over the ecosystems to comparable classes and in comparable manner.

Comparability, continuous use, territorial representativeness and quality were the main standards which were kept in mind while choosing the classification base.

We have chosen for the aggregation to main ecosystem types LULUCF as this is the classification which has been territory wide used for the yearly greenhouse gas reporting. So the upmost level of the ecosystems classification represents the upmost level of LULUCF classification[14]. One could argue that there is not enough ecological features behind LULUCF classification. As we chose the LULUCF just for the most aggregate level of the classification we are of the opinion that the ecological detail is bound on the lowest level of the classification. Aggregation to a top level of known classification would allow the cross checks regarding the consistency and coverage with already known and in use classification. The illustration of the Estonian ecosystem type map according to LULUCF classes is shown in Figure 1.

[13] Paal, J. 1997. Eesti taimkatte kasvukohatüüpide klassifikatsioon. Keskkonnaministeerium & ÜRO Keskkonnaprogramm, Tallinn

[14] Classification is based on documents IPCC Guidelines for Greenhouse Gas Inventories and the IPCC Good Practice Guidance for Land Use, Land-use Change and Forestry

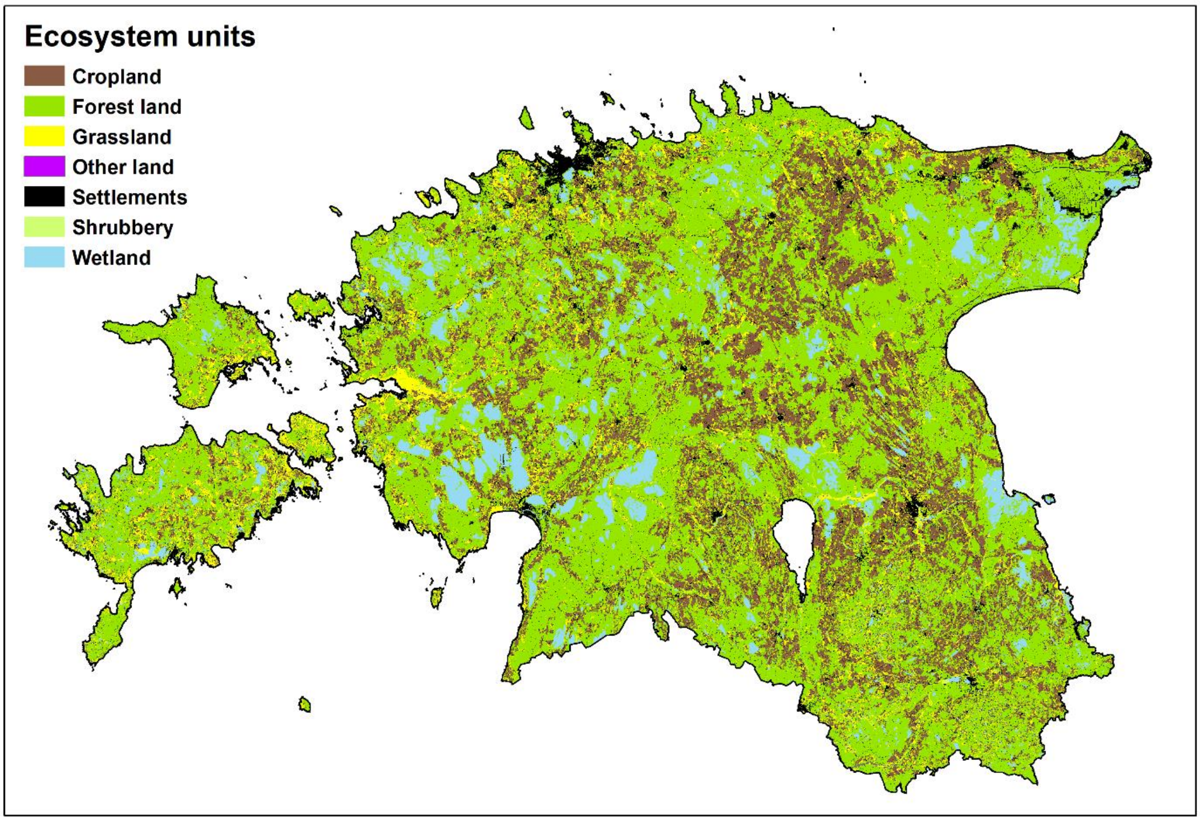

Figure 1. Estonian ecosystem unit base map according to main ecosystem types derived from UNFCCC IPCC LULUCF classes.

2.4.1.1 Updating forest land information

As forest land accounts for over 50% of the land area, more attention has been paid to classifying forests. More or less up-to-date information on about 3/4 of the forest land is available via the Forest Register. This includes detailed forest inventory data.

No further information is available on the rest of the forest defined by Estonian Topographic Database and/or Natura 2000 inventories. However, the soil type of these areas is known according to the soil map [15] (in scale 1:10 000, which covers 99% of the Estonian mainland)[16].

Based on the soil type, the forest site type was determined or predicted using the national classification (Lõhmus, E. 1984)[17] . There are over 30 different forest site types and 71 forest soil types according to the national classification.

In case when soil type corresponds to more than one forest site type the latter has been predicted based on the probability of its occurrence. This probability has been found using the model (based on National

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[15] Kmoch, Alexander, Kanal, Arno, Astover, Alar, Kull, Ain, Virro, Holger, Helm, Aveliina, … Uuemaa, Evelyn. (2019). EstSoil-EH v1.0: An eco-hydrological modelling parameters dataset derived from the Soil Map of Estonia data deposit (Version v1.0) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3473290. Downloadable https://geoportaal.maaamet.ee/est/Andmed-ja-kaardid/Mullastiku-kaart-p33.html

[16] also viewable in a web browser https://xgis.maaamet.ee/maps/XGis?app_id=MA29

[17] Lõhmus, E. 1984. Eesti metsakasvukohatüübid. Lisad, tabel 1. Metsamuldade klassifikatsiooniüksused ja nendele vastavad kasvukohatüübid

Forest Inventory, sample size around 23 thousand plots from years 2005 to 2014). Thus, even if the type predicted for a particular area may not be accurate, the result for a larger area (whole country) is correct.

2.4.2 Upgrading the national map units to the EUNIS habitat classification

The EUNIS habitat classification is a comprehensive pan-European system to facilitate the harmonised description and collection of data across Europe through the use of criteria for habitat identification. Transition of national map units to the EUNIS classification has been made using the EUNIS website that include text descriptions and environmental parameters based on EUNIS habitat classification 2007 - Revised descriptions 2012 amended 2019 [18] .

For each land use class (mapping unit), the best match was determined from the EUNIS classification, to the most detailed level possible. For linking Habitats Directive Annex I habitat types to the EUNIS classification cross-walks between the EUNIS and Annex I habitat types were used.[19]

The results of the conversion of the ecosystem extent to EUNIS classification is presented in Table 2.

Table 2. Opening extent account, classified according to the EUNIS habitat type classes and institutional sectors, ha

Institutional sector	**Coastal**	**Constructed, industrial and other artificial habitats**	**Grasslands and lands dominated by forbs, mosses or lichens**	**Habitat complexes**	**Heathland, scrub and tundra**	**Inland surface waters**	**Inland vegetated or sparsely vegetated habitats**	**Marine**	**Mires, bogs and fens**	**NA**	**Regularly or recently cultivated agricultural, horticultural and domestic**	**Woodland, forest and other wooded land**	**TOTAL**
General government	632	55 190	29 224	5 739	3 333	11 354	19 420	2 439	17 413	202	103 232	113 178	**361 356**
Non-financial corporations	197	25 475	37 323	2 734	3 029	2 780	16 337	1 927	7 402	160	315 063	476 303	**888 730**
Financial corporations	3	110	140	14	20	13	54	21	15	0	363	624	**1 377**
Households	644	80 072	110 059	9 343	10 282	6 712	19 874	9 164	15 606	357	661 207	680 055	**1 603 376**
NPISH	3	1 179	859	226	76	57	358	121	132	1	1 942	2 780	**7 735**
Rest of the world	100	2 498	3 805	457	539	185	591	1 197	536	15	8 377	15 654	**33 954**
State Forest Management Centre	1 353	8 794	29 091	1 926	1 902	18 753	10 551	5 507	201 043	303	6 393	1 049 105	**1 334 720**
Unknown	65	3 259	2 056	178	189	1 242	1 709	132	19 281	23	5 706	81 392	**115 232**
TOTAL	**2 997**	**176 577**	**212 556**	**20 618**	**19 370**	**41 095**	**68 894**	**20 507**	**261 428**	**1 062**	**1 102 284**	**2 419 091**	**4 346 480**

[18] https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification/habitats/eunis-habitats-complete-with-descriptions.xls/at_download/file
[19] https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification/documentation/link-between-eunis-2007-and.xls

The results of the conversion of the ecosystem extent to EUNIS detailed classification types are presented in ANNEX 7 “Land area by institutional sector according to EUNIS habitat classes”.

Forest land, for which more detailed information is available in the Forest Register, could be classified into the lower EUNIS classes according to the characteristics of the forest stand as well. However, this requires a more in-depth analysis, work is planned for the future and for this task no resources were available in this project.

The conversion logic to EUNIS is displayed in ANNEX 5. Problems encountered were that there are certain classes which could be only allocated to the highest level of the EUNIS due to the lack of raw data which does not allow for a more precise distribution.

2.4.3 Links to other land use/habitat/ecosystem types

Analysis of other countries approaches showed that most of the countries are facing the challenges and there is no good answer how to meaningfully go beyond land use and land cover based classification to ecosystems types.

Alternatives to get from land use and cover classification to ecosystems based classification and the feasibility to switch classifications (availability of the “cross walks” between different classifications) were analysed. The suitability of the classification suggested by SEEA-EEA manual classification (USGS/ESRI World Ecosystems) on national level was briefly considered (as this was suggested in manual). World Ecosystems data (UDGS/ESRI) is a 250 m global dataset of biophysically distinct (GDBBS) areas. For this purpose USGS was contacted and the map for Estonia was inquired. USGS/ESRI World Ecosystems data display 14 distinguished broad classes for Estonia (Figure 2). The evaluated granularity for Estonia in the World Ecosystems seems to be quite low compare what we have mapped already in terms of ecosystems units. However our crosswalk to LULUCF comprises also only 6 classes. The accuracy of the World Ecosystems map (global dataset of biophysically distinct - GDBBS) for Estonian ecosystems could be analysed in a future work.

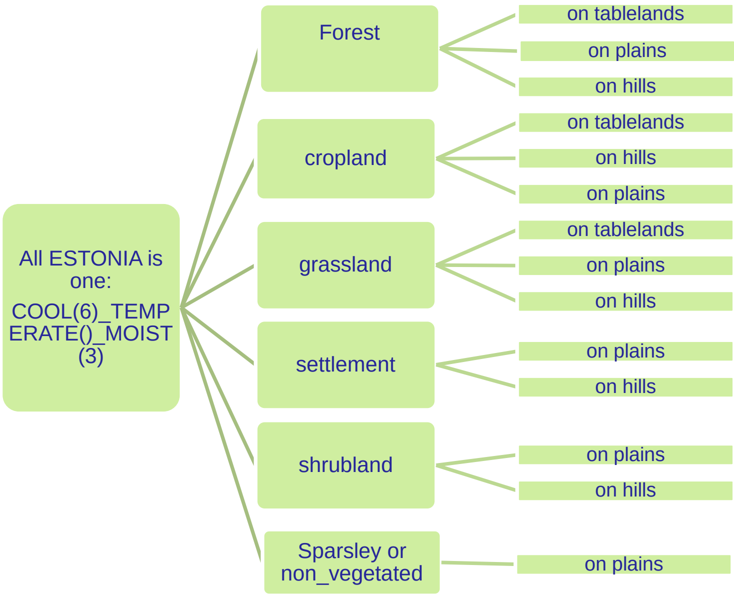

Figure 2. USGS/ESRI World Ecosystems data granularity for Estonia

Distinguishing relatively flat Estonia on the basis of altitude does not seem relevant to us. How well these types match to our own map is too early to say and could be evaluated in next phases.

There is also MAES (Mapping and Assessment of Ecosystems and their Services) ecosystem classification[20] but this classification uses very broad classes and actually mixes both ecosystems with land cover classes. Statistics Netherlands experts suggested testing the application of European MAES classification suitability on national scale as well. Comparisons of Estonian local national MAES classification based map classifications will start when their ecosystem map is completed and becomes available for the discussions (currently it is not yet available). The compatibility with the European MAES classification will be planned as well.

In addition, the IUCN RLE classification suggested by experts was analysed in brief as well. Desired features of IUCN RLE types classification that they represents ecosystems, are spatially delineated, geographically and conceptually exhaustive, mutually exclusive both conceptually and geographically, practicable, linkable to other established classifications are all very relevant. Criteria are very good but IUCN RLE typology has not been used yet and it is not yet available. Crosswalk from national level lowest level classification is probably feasible to level 3 but it was not analysed yet if this level contains enough relevant detail for future analyses. IUCN classification could be analysed further in next year's efforts.

It has been discussed that national classification is preferable as ecosystem classification may well also depend on the need of the users. If broad classes (like land cover/use) satisfy the potential users, it may well be efficient enough then to use those. As the detailed information is relevant and as at the current level of development of the concepts it is not clear yet how extent and the services supply will be linked, the general agreement was agreed in a project group to classify different ecosystems types as detailed as the data allows (as the kind and quality of classification influence the quality of ecosystem services these provide).

[20] Maes, J., A. Teller, M. Erhard, C. Liquete, L. Braat, P. Berry and G. Bidoglio (2013), Mapping and Assessment of Ecosystems and their Services, An Analytical Framework for Ecosystem Assessments under Action 5 of the EU Biodiversity Strategy to 2020, Publications Office of the European Union, Luxembourg.

2.5 Description of the development of the dimension of owners of Estonian „ecosystems“

The effort to add a separate layer to the extent account by economic and institutional dimension was taken. The idea that cadastral parcels would facilitate the linkages to economic units/activities was chosen and tested on a spatially explicit map of ecosystems for Estonia by adding an owner's dimension.

In order to reach this objective the link between ecosystem units and ownership has to be developed at the level of cadastral units, as this kind of connection have not been done in Estonia before. Although it would be desirable to actually link the ecosystem service provision to actual users, but due to lack of reliable data about the users of the land (e.g. land leasers), this options was not pursued in current project. Therefore, we do acknowledge that from the viewpoint of the use of the ecosystem service the owners may not be finally that relevant as may be initially expected, as the real user may not necessarily match with the user. Still the owner's identification is important from the viewpoint of the design of financial instruments for the management of maintenance of ecosystem services.

For the first step, the connection was made between each cadastral unit and the owner as well with economic actors. We used national "Land register" to obtain all the firms and addresses that could be connected to their cadastral units. For the second step the ecosystem unit map was overlaid with the spatial information of land cadastral units and analysed. The classification of institutional sector and activity was identified by linking cadastral data with the data from the Statistical Enterprise Register (SPI) maintained by Statistics Estonia. For some cases the owners of the land parcels were not available from the SPI and assumptions were used to allocate these to institutional sectors. All the owners that were classified in the Land Register as physical persons were identified as households. All the owners that were classified as public institution were identified as general government, all the owners that were classified as juridical persons were identified as corporations and all land owners which citizenship was not Estonian were classified as rest of the world. When economic activity was not available were the category "Unknown" was omitted at current stage. We plan to work with this issue in the next phases of the work on extent account.

State Forest Management Centre (SFMC) was classified separately as it is considered as corporation in national accounts and SPI. As SFMC manages state forest it should not be considered as an ordinary corporation and the meaning and the alternatives regarding the defining of SFMC ownership is important for further analysis. In order to link SFMC as the owner of land parcels also state land register was used. State Land Register was also useful for identifying some of the land owners that were not available from SPI.

One of the following tables (Table 4) displays the opening extent account, classified according to economic activities on NACE 21 level (except for NACE A that is more detailed and also State Forest Management Centre is separated) and another table (Table 5, Table 6) displays the opening extent account, classified according to institutional sectors. Tables reveal that the largest extent is under forest land which largest owner is State Forest Management Centre. State Forest Management Centre is also the biggest owner of wetlands. In Table 3 it can be seen that the biggest land owner among economic activities is NACE A.01 – Crop and animal production, hunting and related activities but it is important to consider that the activity also includes households. Rest of the world is the owner of almost 1% of the land. Still almost 3% of the extent is yet unknown and waits for the improvements in databases.

The closing extent account will be composed in the next phase of the work. Having an ownership dimension will provide valuable information in changes of the ownership pattern of ecosystems.

We can see also that households are the biggest owners of grasslands (35%), the biggest owners of settlements (32%) as well as the biggest owners (34%) of shrubbery. The households are the second biggest owner of cropland (34%) and the forest land and other land. Many households are however renting out their cropland as well as grasslands for agricultural companies or other juridical person. Agricultural subsidies paid to physical persons (households) are considered as income and are being taxed by income tax (or the tax is with hold when subsidies are paid out). Subsidies paid to juridical persons are not taxed. Compiled accounts and their time series would be useful for analysis of the equality aspects of the fiscal measures in future and also for the analysis of the impacts of the tax policy on ecosystems management, economy and society. Following table highlights in green colour biggest owner categories (economic activities and households) of the respective land (ecosystem) categories and in pink colour the smallest ones.

Table 3. Distribution of the land use (ecosystem) categories by economic activites and households (biggest owners of the ecosystems land are in green and the smallest in red colour)

	NACE	Cropland	Forest lanc	Grassland	Other land	Settlemen	Shrubbery	Wetland	TOTAL	Share, %
Crop and animal production, hunting and related service activities	A.01	39%	8%	25%	6%	10%	19%	2%	665 551	15,3
Forestry and logging	A.02	7%	17%	7%	7%	4%	7%	2%		12,2
Fishing and aquaculture	A.03	0%	0%	0%	1%	0%	0%	0%	6 960	0,2
Mining and quarrying	B	0%	0%	0%	0%	1%	0%	0%	5 299	0,1
Manufacturing	C	1%	0%	1%	1%	2%	1%	0%	22 147	0,5
Electricity, gas, steam and air conditioning supply	D	0%	0%	0%	1%	1%	0%	0%	6 591	0,2
Water supply; sewerage; waste management and remediation activities	E	0%	0%	0%	0%	0%	0%	0%	1 905	0
Construction	F	0%	0%	1%	1%	1%	1%	0%	16 138	0,4
Wholesale and retail trade; repair of motor vehicles and motorcycles	G	1%	1%	1%	1%	1%	1%	0%	27 052	0,6
Transporting and storage	H	1%	0%	1%	1%	2%	1%	0%	20 907	0,5
Accommodation and food service activities	I	0%	0%	0%	0%	0%	1%	0%	7 051	0,2
Information and communication	J	0%	0%	0%	0%	0%	0%	0%	3 901	0,1
Financial and insurance activities	K	0%	0%	0%	0%	0%	0%	0%	3 115	0,1
Real estate activities	L	6%	1%	3%	3%	4%	3%	0%	104 707	2,4
Professional, scientific and technical activities	M	1%	0%	1%	1%	1%	1%	0%	18 011	0,4
Administrative and support service activities	N	1%	0%	1%	0%	1%	1%	0%	18 019	0,4
Public administration and defence; compulsory social security	O	7%	3%	10%	5%	14%	9%	10%	249 874	5,7
Education	P	0%	0%	0%	0%	0%	0%	0%	14 555	0,3
Human health and social work activities	Q	0%	0%	0%	0%	0%	0%	0%	3 524	0,1
Arts, entertainment and recreation	R	0%	0%	0%	0%	1%	0%	0%	9 988	0,2
Other services activities	S	1%	0%	1%	1%	1%	1%	0%	19 960	0,5
OTHER		1%	1%	3%	16%	12%	8%	4%	103 788	2,4
State Forest Management Centre	A.02	0%	43%	8%	30%	8%	10%	68%	1 334 646	30,7
Households		34%	18%	35%	22%	32%	34%	5%	1 004 563	23,1
Rest of the world		1%	1%	2%	3%	1%	2%	0%	33 954	0,8
Unknown		1%	3%	1%	1%	2%	1%	6%	115 232	2,7
TOTAL		100%	100%	100%	100%	100%	100%	100%	4 346 480	100
Share, %		19,4	55,7	11,5	0,2	5,4	0,4	7,5	100	

Table 4. Opening extent account, classified according to the closest broad classes of the UNFCCC/IPCC land use classes (LULUCF) and economic sectors,ha.

	NACE	Cropland	Forest land	Grassland	Other land	Settlements	Shrubbery	Wetland	TOTAL	Share, %
Crop and animal production, hunting and related service activities	A.01	324 666	184 815	122 222	454	23 413	3 403	6 579	**665 551**	15,3
Forestry and logging	A.02	56 183	419 017	35 514	572	9 627	1 265	6 865	**529 043**	12,2
Fishing and aquaculture	A.03	924	3 291	1 687	59	493	86	419	**6 960**	0,2
Mining and quarrying	B	827	2 016	550	5	1 405	38	458	**5 299**	0,1
Manufacturing	C	4 267	9 984	2 793	46	4 607	106	344	**22 147**	0,5
Electricity, gas, steam and air conditioning	D	587	2 358	1 347	43	1 677	44	534	**6 591**	0,2
Water supply; sewerage; waste management	E	157	347	381	10	822	14	174	**1 905**	0,0
Construction	F	3 764	6 940	2 784	58	2 249	108	235	**16 138**	0,4
Wholesale and retail trade; repair of motor vehicles and motorcycles	G	5 217	14 441	3 832	51	2 880	161	470	**27 052**	0,6
Transporting and storage	H	5 088	7 121	2 987	64	5 130	134	382	**20 907**	0,5
Accommodation and food service activities	I	1 133	3 237	1 625	28	718	92	218	**7 051**	0,2
Information and communication	J	914	1 637	913	9	340	31	57	**3 901**	0,1
Financial and insurance activities	K	809	1 384	558	10	283	24	47	**3 115**	0,1
Real estate activities	L	47 304	30 456	15 910	216	9 066	548	1 207	**104 707**	2,4
Professional, scientific and technical activities	M	5 022	7 428	3 386	45	1 683	149	298	**18 011**	0,4
Administrative and support service activities	N	4 602	8 042	3 404	40	1 518	135	277	**18 019**	0,4
Public administration and defence; compulsory	O	62 167	72 557	47 649	423	33 587	1 654	31 837	**249 874**	5,7
Education	P	1 725	10 431	1 181	10	847	34	326	**14 555**	0,3
Human health and social work activities	Q	907	1 370	579	4	586	16	62	**3 524**	0,1
Arts, entertainment and recreation	R	1 915	4 348	1 948	31	1 402	70	275	**9 988**	0,2
Other services activities	S	5 260	8 224	4 003	55	1 868	147	403	**19 960**	0,5
OTHER		8 657	33 424	15 967	1 305	28 359	1 458	14 618	**103 788**	2,4
State Forest Management Centre	A.02	2 856	1 049 945	39 261	2 468	17 998	1 761	221 258	**1 334 646**	30,7
Households		287 202	440 133	176 876	1 750	75 875	6 217	16 501	**1 004 563**	23,1
Rest of the world		5 920	15 654	7 780	209	3 340	309	742	**33 954**	0,8
Unknown		4 502	81 392	3 369	121	4 683	162	21 003	**115 232**	2,7
	TOTAL	**842 574**	**2 419 091**	**498 506**	**8 096**	**234 456**	**18 168**	**325 589**	**4 346 480**	**100**
	Share	19,4	55,7	11,5	0,2	5,4	0,4	7,5	**100**	

Table 5. Opening extent account, classified according to the closest broad classes of the UNFCCC/IPCC land use classes (LULUCF) and institutional sectors, ha

Institutional sector	**Croplan**	**Forest**	**Grassla**	**Other**	**Settlem**	**Shrubbe**	**Wetlan**	**TOTAL**
General government	71 033	113 178	63 176	1 705	62 581	3 083	46 600	**361 356**
Non-financial corporations	262 487	476 303	91 933	1 104	42 595	3 126	11 181	**888 730**
Financial corporations	266	624	263	7	173	13	31	**1 377**
Households	494 158	680 055	291 147	2 456	101 418	9 646	24 497	**1 603**
NPISH	1 344	2 780	1 576	26	1 664	68	277	**7 735**
Rest of the world	5 920	15 654	7 780	209	3 340	309	742	**33 954**
State Forest Management Centre	2 864	1 049	39 262	2 468	18 002	1 761	221 258	**1 334**
Unknown	4 502	81 392	3 369	121	4 683	162	21 003	**115 232**
TOTAL	**842 574**	**2 419**	**498 506**	**8 096**	**234 456**	**18 168**	**325 589**	**4 346**
Percentage	19	56	11	0	5	0	7	**100**

*-Shrubbery class is separated from grassland in this table / project, although classified as Grassland in the LULUCF classification.

Table 6. Opening extent account, classified according to the closest broad classes of the UNFCCC/IPCC land use classes (LULUCF) and institutional sectors, shares in percentages.

Institutional sector	**Cropland**	**Forest land**	**Grassland**	**Other land**	**Settlements**	**Shrubbery**	**Wetland**	**Share of sector in total**
General government	8	5	13	21	27	17	14	8
Non-financial corporations	31	20	18	14	18	17	3	20
Financial corporations	0	0	0	0	0	0	0	0
Households	59	28	58	30	43	53	8	37
NPISH	0	0	0	0	1	0	0	0
Rest of the world	1	1	2	3	1	2	0	1
State Forest Management Centre	0	43	8	30	8	10	68	31
Unknown	1	3	1	1	2	1	6	3
Share of ecosystem category in total	19	56	11	0	5	0	7	100

The dimension of the ownership was also created according to the EUNIS habitat classes, the table is displayed in ANNEX 8. The analyse respective oto wnersip dimension would be carried out when timeseries will be created, other countries data will become available or the link to other economic (fiscal) data will be created in next periods.

2.6 Grasslands categorisation and handling in the ecosystem accounts

2.6.1 Estonian grasslands classification in ecosystem accounts

At the beginning of the current work the agreed uniform classification of the grasslands was not available. From the functional perspective grasslands had to be split at least between semi-natural and cultivated. Two main classes were formed for analytical purposes: cultivated and semi-natural grasslands. Main difference lays in fact that cultivated grasslands are important for their agricultural production value and semi-natural grasslands have generally high biodiversity therefore having high conservation value. The disaggregation to most detailed mapping units is available in ecosystem unit map for ecosystem extent account (ANNEX 5. Both for the sake of compilation of opening extent account and ecosystem services account the attempt was made to classify the grasslands uniformly depending on their specific features and specific user needs.

As described in the chapter of the overview of studies carried out in Estonia, the multi-tiered approach for grassland ecosystem services mapping and assessment (*Viva Grass*[21]) was done in Estonia last year. Grassland types were handled as follows: cultivated grassland, permanent grassland and semi-natural grassland. Cultivated grassland is created by sowing with an aim to produce as much grass as possible. Cultivated grasslands are usually heavily used, fertilized and their biota is rather poor. Permanent grassland has not been cultivated for at least five years. Permanent grassland usually originates from formerly cultivated grassland or arable land. Permanent grasslands are used for animal feed or grazing, like grasslands, but compared to the latter, permanent grasslands are more species-rich and therefore of higher natural value. Semi-natural grassland is a habitat formed by long-term mowing or grazing that is not generally fertilized or heavily used. They are very rich in species and of high nature value, so many

[21] , Kalev Sepp , Justas Gulbinas. A multitiered approach for grassland ecosystem services mapping and assessment: The Viva Grass tool. LIFE Viva Grass homepage. https://vivagrass.eu/ee/grasslands/variety-of-grassland/

of them have been included in the Natura 2000 network to ensure the protection of rare or endangered species and habitats.

Based on information available from various databases and expert judgment grasslands were divided into classes, which received a code number as seen in column 1 in Table 7. The final position and decision of the discussion is shown in column 4. The established grassland ecosystem classification is the basis for allocation of grassland ecosystem services. Grassland ecosystem classification is displayed also in ANNEX 4.

The classification applied covers all grassland related entries to the explicit map, which refer to the following registers and databases: Estonian National Topographic Database, Estonian Agricultural Registers and Information Board, Forest registry of Estonia, Estonian Nature Foundation, Estonian Environment Agency, and Estonian Semi-natural Community Conservation Association. The relations between registers classification where ecosystem map layers are derived from and grassland types are displayed in ANNEX 3.

Grassland classification has been discussed in various meetings (ANNEX 1, ANNEX 2 and several team meetings), open issues are displayed in Table 7. Classification of the borderline cases between grassland and wetland ecosystems, grassland and forest ecosystems and grassland and agricultural ecosystems were discussed. Argo Ronk and Veiko Adermann as members of the project; Aveliina Helm as meadow specialist at the ELME project, and Reimo Rivis, associate professor of ecology at Tallinn University, participated in the discussion. Classification was presented and disseminated at the methodological seminar in November 2019. The table below shows the views and results of the discussion. The deleted and initially considered entries are: Boreal Baltic sandy beaches with perennial vegetation (1640, as certain subtypes may be considered grassland, but generally shallow and sparse vegetation), Alcaline fens (7230, in most cases bog. In the environmental register database they are meadows but in NATURA database these are bogs).

Table 7. Classification of grassland ecosystems

Level	Ecosystem type	Status
1.	Grassland	
1.1.	Semi-natural grassland	
1.1.1.	Semi-natural grasslands according to the NATURA classification	
1.1.1.1.	1630 - Boreal baltic coastal meadows	Confirmed
1.1.1.2.	2130 - Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	A dune area that may be heathy grassland. Typical beach meadow. Confirmed.
1.1.1.3.	2320 - Dry sand heaths with Calluna and Empetrum nigrum	A dry sand heaths; more loose sand compared to 2330; coastal grasslands. Confirmed.
1.1.1.4.	2330 - Inland dunes with open Corynephorus and Agrostis	Dry sand heaths, coastal grasslands. Confirmed. added
1.1.1.5.	4030 - European dry heaths	Confirmed
1.1.1.6.	5130 - Juniperus communis formations on heaths or calcareous grasslands	Confirmed
1.1.1.7.	6120 - Xeric sand calcareous grasslands	Confirmed
1.1.1.8.	6130 - Calaminarian grasslands of the Violetalia calaminariae	Confirmed
1.1.1.9.	6210 - Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	Confirmed
1.1.1.10.	6270 - Fennoscandian lowland species-rich dry to mesic grasslands	Confirmed
1.1.1.11.	6280 - Nordic alvar and precambrian calcareous flatrocks	Confirmed
1.1.1.12.	6410 - Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	Confirmed
1.1.1.13.	6430 - Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	Confirmed
1.1.1.14.	6450 - Northern boreal alluvial meadows	Confirmed
1.1.1.15.	6510 - Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	Confirmed
1.1.1.16.	6530 - Fennoscandian wooded meadows	Very thin forest, more like grassland. Move to forest partially in future?
1.1.1.17.	9070 - Fennoscandian wooded pastures	Single small pieces of forest with large patches of grassland.
1.1.2.	Other semi-natural grassland*	Confirmed
1.2.	Cultivated grassland	Confirmed
1.2.1.	Permanent grassland	Confirmed
1.2.1.1.	Environmental non-sensitive permanent grassland	Confirmed
1.2.1.2.	Environmental sensitive permanent grassland	Confirmed
Memo items**		
2.	Agricultural land	
	Short term grassland	Agreed that this is agricultural land. Exclude from grasslands.
	Short term grassland	Exclude from grasslands
	Restored grassland	Exclude from grasslands

* - other semi-natural grassland refer for the grasslands which have been identified according to the presence on Estonian topographic map and for which no other information is available.

** - memo item: short term grasslands are not part of the grasslands and are considered to be agricultural land. They are displayed from the point of view of general information.

It should be kept in mind that currently most of the “ecosystem typology classes” are land use, land cover classifications. So, other important parameters to consider (soil, climate, water regime, habitats) need to be further clarified to grasp more complexity.

Grassland classification could be revisited in the next phases ecosystem services account compilation when the borderline classes will be handled from the perspective of other classes like wetlands and forests. It is also important to consider the feedback from the users.

Developed grassland classification was used for the compilation of an extent account and for valuation of ecosystem services.

2.6.2 The ownership dimension of Estonian grasslands ecosystem extent account

One of the results of current work under this grant was adding an ownership dimension to extent account linking ecosystem units with the owner by the categories in sense of economic activities and institutional sectors. On detailed level the analysis was done for grassland ecosystem types. The ownership of Estonian grassland ecosystem types by activity sector is displayed in ANNEX 6.

We hope that ecosystem extent account would facilitate the better analysis of the use and management of the grassland ecosystems. After the compilation of the closing stock in the next phases of the development of the work the annual change in different dimensions of extent account would become available also for grasslands. This will provide the changes in ownership of grasslands and simultaneously the changes in land use. The latter is associated with the changes in related ecosystems. As land owners are generally not motivated in managing semi-natural ecosystems on their own expenses (i.e. without subsidies) the more advanced analyses of effects of financial instruments and regulatory framework is needed. Hopefully more relevant and more effective measures could be developed by linking the information available in registers and in national accounts on subsidies received and taxes paid. Both categories (ecosystem types and land ownership) are linked in the developed extent account.

The extent account provides the possibility to monitor the change in ownership: it is also important to see, which economic sectors and which kind of owners are responsible for the management of valuable ecosystems contributing to the provisioning of the bunch of market and non-market ecosystem service flows. In addition to the ownership of the land and related ecosystem services it is relevant to know, record and analyse the actual managers and users of the land and ecosystems, as it is quite often the case that land is leased to other users (economic operators). From the viewpoint of the design of the instruments it might be particularly vital to understand what is the potential volume and heterogeneity of the service flow in case of each ecosystem of interest as well as who are owners and actual managers of those services.

Designers of the instruments have lacked the monitoring land ownership patterns based on continuous series of data and had to base the design of the instruments on single analytical studies and on rather scattered statistics. More evidence would be available if data of various registers will be linked.

3. Development of the methodology for the valuation of grassland ecosystem services

3.1 Overview of the studies: Relevant national studies and articles on grasslands ecosystem services

Monetary valuation of ecosystem services regarding grassland ecosystem services was planned. The results of the valuations were then to be assembled in a supply and use table of ecosystem services that would allow further analysis.

Ecosystem services accounts following the concept presented in UN SEEA EEA have not yet been compiled in Estonia. There are some studies available regarding the ecosystem services mapping and assessment in Estonia. However these are mostly focusing on a single ecosystem where either biophysical modelling or monetary valuation of its services have been carried out. Therefore the goal of the current grant project to develop ecosystem services account for a broad class of ecosystems that includes subclasses is both innovative and important.

Current chapter provides an overview of previous works done on the topic of the assessment of the ecosystem services supplied by Estonian grasslands.

3.1.1 Estonian studies relevant to the biophysical modelling of the ecosystem services of grasslands

The project "Integrated planning tool to ensure viability of grasslands" (acronym – LIFE Viva Grass)[22] defines grassland ecosystem services as all benefits that an ecosystem provides to humans. They include provisional (goods that can directly be used by human), regulating (benefits gained from processes in nature) and cultural (non-material) services. The legend shows supply potential of a selected ecosystem service expressed in a relative scale from 1 (very low) to 5 (very high), where 0 stands for no service provided. The services were evaluated by expert based ranking approach. Ecosystem services are divided into 3 groups according Common International Classification of Ecosystem Services (CICES): Provisioning services – hay for animal feeding, biomass for energy production, herbs for medicinal treatment, genetic resources; Regulating services – water regulation, soil retention, nutrient regulation, pollination; Cultural services – rural and urban landscape and its aesthetic qualities and cultural heritage, providing basis for recreation and tourism, as well as quality of life for living in that area.

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[22] Integrated planning tool to ensure viability of grasslands (acronym – LIFE Viva Grass) aimed to prevent loss of High Nature Value grasslands and increase effectiveness of semi-natural grassland management by developing the Integrating Planning Tool (Tool). The tool based on ecosystem services approach helps to strengthen linkages between social, economic, environmental, agricultural fields and policies in grassland management. Results of the tool helps planning and decision taking in sustainable grassland management. The Project is implemented in 9 demo areas in 3 Baltic states. (implementation period: 06/2014 – 04/2019). One of the project actions is Grassland ecosystem service assessment at the selected case study areas; https://vivagrass.eu/about-the-project/.

Related article[23] shows the presence of grassland ecosystem services in the studied areas, but does not value the grassland ecosystem services in monetary terms. Study remains too general but it captures the current knowledge in the area of grassland ecosystem services biophysical modelling.

A key requirement of the study was to develop an ecosystem services mapping and assessment based on a common classification of grassland types. The potential delivery of ecosystem services is determined by the interaction of natural capital attributes, comprising both biotic and abiotic component and human inputs and management strategies.

The grassland classes that constitute the Viva Grass base map have been defined according to two main factors: *1. The underlying natural conditions*: Two factors have been selected as descriptors of the environmental conditions that underpin the provision of ecosystem services in the grasslands of the Baltic States: Land quality and slope. *2. The management regime of the grasslands*: Three types of grassland management regimes and one type of cropland have been considered in the analysis as the foundation for creating the ecosystem services supply potential base map, namely: cultivated, permanent, semi-natural grasslands and arable/cropland.

The paper states that the grassland classes alone do not account for the spatial dimension of ecosystem services. Service Providing Areas (SPAs) constitute the best way to spatially capture the complex ecological systems that underlie the delivery of ecosystem services. Service Providing Areas can be defined as spatially delineated units that encompass entire ecosystems, their integral populations and the underlying natural capital attributes. In the paper is presented ecosystem services indicators and factors determining ecosystem services potential. The authors claim that qualitative nature of expert-based assessments is not an obstacle for deeper, statistics-based analysis. A Principal Components Analysis has been carried out using the qualitative scores for grassland plots (observations) and ecosystem services (variables) based on the matrix as input data. In tier 2 is given a list of cultural ecosystem services (1. physical and experiential interactions; 2. educational; 3. cultural heritage; 4. aesthetics) and their evaluation criteria. At the third tier, the SPAs are further enriched with additional information (e.g. annex I habitat type and conservation status). The outputs of each tier answer different policy- and decision-making questions and the results of each tier feed into the next tier level as source data.

At tier 1, the outputs of the three-step expert-based assessment were gathered in a grassland ecosystem services matrix. At tier 2, the PCA revealed 3 main components which correspond to three bundles accounting for 90.53% of the total variance. In the cases when data was available, MCDA models were developed and integrated into tier 3 in order to answer specific grassland-related policy questions.

Our project team considered the slope aspect not relevant and provided grassland classes to be too general for being a sufficient bases for analysing spatial dimension of ecosystem services monetary value in Statistics Estonia study under way.

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[23] Miguel Villoslada, Ivo Vinogradovs, Anda Ruskule, Kristina Veidemane, Olgerts Nikodemus, Raimonds Kasparinskis , Kalev Sepp , Justas Gulbinas. A multitiered approach for grassland ecosystem services mapping and assessment: The Viva Grass tool.

The study by Tambet Kikas et al. [24] on the application of an expert system to integrate biodiversity, landscape and land use management indicators demonstrates the impact of grasslands on the value of the agricultural land but does not value directly ecosystem services provided by grasslands. Study describes the construction of expert system-based tool to map High Nature Value (HNV) agricultural land in Estonia. Twenty appropriate indicators from four thematic groups, i.e., land use management, nature conservation, landscape diversity and inherent natural quality, have been selected on the basis of use in the literature, the requirement of consistent national datasets and statistical analysis.

Despite the limited applicability for the valuation of the ecosystem services the study is a step towards compilation of the national grassland databases and defining of the methods. In this paper, the term agricultural land is used rather than agricultural landscape because the latter can contain forests and wetlands, which in Estonia at present are not used by farmers nor used to calculate farm subsidies, unless there are less than 50 trees per hectare (e.g., wooded meadows).

Agricultural land 1 km squares all over Estonia are evaluated according to the occurrence of HNV parameters. The HNV parameters directly associated with grasslands are as follows (the occurrence of the parameters is evaluated on a scale of one to five):

- Group 1. Land use management.
- G11 Permanent grassland on agricultural land, derived from IACS and LPIS data as% of UAA.
- G12 Short-term grassland on agricultural land, derived from IACS data as% of UAA.
- Group 2. Nature conservation.
- G21 Semi-natural habitats on agricultural land derived from EELIS for SNH land as% of UAA.
- G22 Managed semi-natural habitats on agricultural land derived from EELIS for managed SNH land as% of UAA.

In addition, other parameters are also indirectly affected by the presence of grassland in the evaluated square kilometres.

The work was important as it provides additional alternative information about grassland ecosystem services because of the high nature value of the ecosystem typically reveals due to biodiversity or habitat service of the ecosystem. Areas with a high HNV status on the Likert scale also need special attention when evaluating ecosystem services.

The overview of Tiina and Tõnu Talvi on semi-natural community’s protection and maintenance [25] provides a view of distribution, management and conservation values of typical semi-natural meadows in Estonia. Study is relevant from the viewpoint of interpretation of management practices of different kinds of semi-natural habitats.

3.1.2 Estonian studies relevant to the valuation of the ecosystem services of grasslands

Studies carried are methodologically relevant but data are outdated in several occasions as economy has grown (gross domestic product has grown a lot in recent decades) and economical structure has changed a lot. However the methods applied have given bases for a current contingent valuation studies.

[24] Tambet Kikas, Robert G.H. Bunce, Ain Kull, Kalev Sepp. New high nature value map of Estonian agricultural land: Applicationof an expert system to integrate biodiversity, landscape and land use management indicators “

[25] Tiina Talvi, Tõnu Talvi. Poollooduslikud kooslused. Kaitse ja hooldus. Viidumäe_Tallinn 2012. In Estonian (Semi-natural communities. Protection and maintenance.) https://www.keskkonnaamet.ee/sites/default/public/PLK/poollooduslikud_kooslused.pdf

3.1.2.1 Market valuation

The Indrek Melts' study on energy potential of herbaceous biomass of semi-natural grasslands in Estonia presents the area and the energy potential of semi-natural meadows by counties[26].

The most important conclusion of the study is, that the total energetic potential of renewable herbaceous biomass in Estonia is (3.3 PJ or 934 GW · h) and it could cover about 2% of total primary energy consumption in 2010.

The study of Marju Aamisepp and Helle Persitski [27] provide profit calculations for crop and livestock production and gives a detailed overview of the cultivation costs of different cultivated hay varieties. For example, the average yield of field grass is estimated to be around 16 tonnes per hectare per year.

3.1.2.2 Non-market valuation

First time the non-market value of semi-natural grasslands has been evaluated using the contingent valuation method in Estonia was in 2001. The study [28] of Ehrlich, Ü and Habicht, K was published in 2001 on the non-use value and maintenance costs of Estonian ecological semi-natural communities. The study deals with the economic and social reasons why the area of semi-natural habitats in Estonia has decreased. The cost of managing semi-natural habitats in Estonia is also analysed by type of habitat.

Historical dynamics of the semi-natural grasslands and overview of the management prices of semi-natural meadows in Estonia nowadays and the subsidies paid for management by types of meadows is provided in a study of Lepasaar, H and Ehrlich, Ü. in 2015. "Non-market value of Estonian semi-natural grasslands: a contingent valuation study." [29] The study reports that, at the beginning of the 20th century, there were 1.8 million hectares of semi-natural grasslands, including 0.86 million hectares of wooded meadows, whereas by the beginning of the 21st century there are 130,000 hectares of semi-natural grasslands, including 8,000 hectares of wooded meadows. The results of a contingent valuation study to find the WTP of Estonian inhabitants for maintaining semi-natural meadows has been also presented. This contingent valuation study has included 1078 respondents. 72 percent of the respondents had positive WTP for maintenance of semi-natural grasslands. The total aggregated WTP was 17.9 million €. The amount of WTP was most influenced by the income, gender and educational level of the respondents. This study has historical value, it allows to see the dynamics of WTP for grasslands maintenance. The main disadvantage of the work is that it does not provide information on respondents'

[26] Indrek Melts, Katrin Heinsoo, Marek Sammul1, Linnar Pärn. Poolloodusllike rohumaade rohtse biomassi energeetiline potentsiaal Eestis. (Energy potential of herbaceous biomass of semi-natural grasslands in Estonian.) https://energiatalgud.ee/img_auth.php/d/db/TEUK2008.pdf

[27] Maamajanduse Infokeskus. Kattetulu arvestused taime-ja loomakasvatuses (koostajad Marju Aamisepp, Helle Persitski) In Estonian. (Coverage profit calculations for crop and livestock production). https://dea.digar.ee/cgi-bin/dea?a=d&d=JVkattetulu201705.2.6

[28] Ehrlich, Ü.; Habicht, K. (2001). Non-Use Value and Maintenance Costs of Estonian Ecological Semi-natural Communities. In: Ü. Ennuste and L. Wilder (Editors Abbr). Factors of Convergence: A Collection for the Analysis of Estonian Socio-Economic and Institutional Evolution (227−263).. Tallinn: Estonian Institute of Economics at TTU. (The study is not ava ilable in digital format)

[29] Lepasaar, H.; Ehrlich, Ü. (2015). Non-market value of Estonian semi-natural grasslands: a contingent valuation study. Discussions on Estonian Economic policy, 2, 49-73.

preferences of grassland ecosystem services. Therefore, it is not possible to allocate total willingness to pay to individual ecosystem services.

The study Ing-Marie Gren, Üllas Ehrlich, Michael Brinch Pedersen[30] on economic valuation of flood plains and coastal wetlands in Estonia deals with various ecosystem services of semi-natural wetlands in Estonia, such as flood plains and coastal meadows. The following values were studied: harvest values, recreational values, life support services, biodiversity values. Recreational values, life-support services and biodiversity values were estimated at a conceptual level. The monetary value is attributed in this study to the harvest values (fodder production). The harvest values are calculated as the associated changes in producers surplus, which are estimated by means of the market prices of the good in question minus the cost of obtaining the good for a single year.

A noteworthy additional finding of this work is the gross value of the river Emajõgi flood plains (river meadows) contribution to fish production, which was approximately 2.3 million € annually. The annual harvest value of Estonian river meadows as hay producers varied between 29 €/ha to 162 €/ha. In addition, value of river meadows and coastal meadows as nitrogen sink was detected. For both river meadows and coastal meadows, the estimated total value varied considerably, 19-596 €/ha/year for coastal meadows and 116-383 €/ha year for river meadows. However for today, the unit prices for hay and reed production calculated in 1995 have become outdated as economy has changed.

From the above overview of the work done so far it could be concluded that there are currently no relevant sufficiently wide and actual study on ecosystem services that could cover all important ecosystem services and what could be extensively used in this work. The need for the crosscutting studies and comprehensive economic analyses is obvious as available studies either focus on certain ecosystem or certain service.

3.2 Selection of ecosystem services

Expert consultations, a seminar and meetings involving interested parties, experts, ELME team (responsible for abovementioned wide scale biophysical modelling of ecosystem services) and Estonian MAES (Mapping and Assessment of Ecosystem Services) team were already held at the beginning of the project in order to determine which ecosystem services can and should be evaluated and which valuation methods could be used. Simultaneously the experts involved in monetary valuations of various ecosystem services in Estonia but also the experts who are more advanced in the field of ecosystem accounting (Statistics Netherlands and UK DEFRA) were consulted for the development of the methodology.

The selection of the ecosystem services to be assessed was based on work done in Estonia so far.[31] The selection of the ecosystem services to be evaluated was done based on the relevance of the services, availability of the data and implementation of the methodology. If at first we assumed that we would need the physical supply of ecosystem services from ELME team (they started a rather large-scale

[30] Ing-Marie Gren, Üllas Ehrlich, Michael Brinch Pedersen. Economic Valuation of Flood Plains and Coastal Wetlands in Estonia, WWF 1995. (The study is not available in digital format)

[31] Tõnu Oja, Uku Varblane, Anneli Palo, Jaanus Veemaa. „Ökosüsteemide teenuste kaardistamise ja hindamise tegevuskava“ Tartu, 2018. Project „Elurikkuse sotsiaal-majanduslikult ja kliimamuutustega seostatud keskkonnaseisundi hindamiseks, prognoosiks ja andmete kättesaadavuse tagamiseks vajalikud töövahendid“

biophysical modelling project simultaneously in 2019) then during the project work we resumed that ELME team will assess potential physical supply, not actual supply that we should base our monetary valuation on. We had a joint meetings with ELME group and we had a stakeholders meeting on 2.04.2019 to discuss which ecosystem services they consider important to value monetarily. A final discussion with stakeholders was held on 09.05.2019. The results of the importance of the services to different parties is available in table in ANNEX 8.

The main objective of ELME project is to develop methodologies both at national and pilot area level to determine the baseline levels of the status of the four ecosystems (forests, wetlands, grasslands and agricultural land) and the provisioning of selected ecosystem services; link the condition of ecosystems and the provisioning of ecosystem services; and to assess the changes in the delivery of ecosystem services related to change. All developed methodologies would be first applied in pilot areas. By autumn 2019, it became clear that the ELME project deadline will be extended as volume of work increased. Due to the change in the time schedule of ELME project, we were not able to use their results. Therefore, despite the fact that the results of the ELME project would have been a good input for this project, indirect data had to be used. Experts involved in monetary valuations of various ecosystem services in Estonia but also the experts from other statistical offices who are more advanced in the field of ecosystem accounting (Statistics Netherlands and UK DEFRA) were consulted for the development of the methodology in the situation where biophysical values of ecosystem services had yet been compiled.

Three criteria for the prioritization of services from UN SEEA (policy interest, data availability, methodological practicality) were followed in the selection of the ecosystem services to be valued. We composed a consultation information sheet for experts and stakeholders which includes ecosystem services, possible methods, available data and their relevance in work.

Prioritization of the services was an important step and the consultation with the stakeholders and experts provided knowledge regarding the importance of the services in Estonia. Methodological feasibility and clarity was also an important aspect in making the final decision. The significance of the phenomena in Estonian context was another criteria for the selection and this was mainly discussed with project team experts. Significance in terms of economic and political importance was relevant aspect as some ecosystem service may be small in economic value but significant in political sense (i.e. habitats, pollination). That distinction was considered as not everything politically relevant today will be so tomorrow or *vice versa*. We compiled the matrix and assessed the relative availability of data, methodology, political significance etc. of services.

Initially we looked through 15 different ecosystem services and possible methods for their valuation. In our grant proposal we promised to value up to ten services. It was suggested not to focus on too many services in the initial phase of the work and to develop what is feasible first and then try valuing more challenging ones. After the final selection eight ecosystem services were chosen for monetary assessment. The suggestion to focus on and do a more exhaustive research on one of the cultural ecosystem services was given by project expert (DEFRA, Rocky Harris).

3.2.1 Query on the relevance of the ecosystem services to the stakeholders

After the discussions of the services and observed the methods which could be feasible a query was organized in the first months of the grant. Primary idea was to receive the input from the users in order to prioritize and select the services and clarify the interest for the separations between cultural and semi-natural grasslands services. Stakeholder's questionnaire was accompanied by the meeting and a seminar and the initial selection of the services to be evaluated was made. The bottleneck was the clarity of the concepts of ecosystem accounting, classification issues, data sources and suitability of the various methods. Project experts provided theoretical back up for the selection process. During the seminar the concepts of ecosystem accounting, classification issues, data sources and feasible methods were discussed. Project experts also participated in a meeting and provided valuable input in order to build a bridge from statistical community to administrators in environment, rural affairs and planning under financial ministry spheres.

Overview of the ecosystem services and the feasibility of valuation methods is presented in Table 8 and with additional information about the importance of the ecosystem services to stakeholders in ANNEX 8.

3.2.1 Agreeing on the ecosystem services and valuation methods

From the provisioning services it was agreed to cover quite a wide range of services and try out various parallel methods. The distinction between potential and actual supply was noted and the focus was set on actual supply. For the several of these services it was noted by the experts that these could be done in one year and it would be worth starting. However the warning was given as well that at the first attempt we might get just indicative figures anyway.

Regarding the regulating services we have planned to evaluate some of the regulatory services , for example a habitat provisioning was picked up indicatively in our grant proposal but it seems that there are general theoretical doubts and different opinions about the nature and accountability of this is service and that it might be difficult to evaluate. We had the methods on table and we discussed how to value services of pollination (avoided cost method), flood protection (highly spatially variable and needs modelling), maintenance of soil quality (relevance of the service in Estonia), and carbon sequestration (using price of tradeable CO_2 quotas).

Regarding regulatory services the discussions with the experts led us to the decision that we could try the valuation of the pollination service as part of the habitat provisioning and carbon sequestration.

Flood protection service was also a candidate for valuation – But as there are two spatially variable aspects: 1) service, 2) economic impact it was noted by the experts that the replacement cost, or damage cost would be both spatially very variable depending on the location of economic assets. As both the supply and valuation of the service would be spatially detailed and modelling would require high resolution (10 m) in order to estimate the contribution of ecosystem to reduction of flood risk it was decided that it would be too early to try to apply a generalized unit cost without some kind of spatial analysis.

Table 8. Grassland ecosystem services evaluated and the approaches for valuation discussed. Green - feasible method, black - method tbc (to be considered), red- method not applicable

TYPE	ECOSYSTEM SERVICE	METHOD semi-natural and agricultural grasslands
Provisioning services	Fodder	1. Resource rent approach
		2. Rent price approach
		3. Benefit transfer (using values from other studies)
		4. Expenditure based method
		5. Market price approach: agriculture statistics
		6. Market price approach: MFA
		7. Hybrid approach: combination of resource rent and market price approaches
		6. CVM
	Medical herbs	1. Direct market price
		2. Benefit transfer
		3. CVM
	Raw material for bioenergy	1. Direct market price
	Food (a) (agriculture, livestock)	*Excluded. We already valuate livestock production through animal feed*
	Food (b) (wild plants, wild animals, fish)	1. Direct market price for wild game (trans-ecosystem)
Regulating services	Protection from flooding	*1. Avoided cost method (trans-ecosystem)*
		2. Benefit transfer
		3. CVM
	Pollination	1. Avoided cost method (trans-ecosystem)
		2. Benefit transfer
		3. CVM
	Habitats for species	*1. Expenditure based method (costs for species and habitat protection)*
		2. Expenditure based method (semi-natural grasslands restoration and upkeep costs)
		3. CVM
	Maintenance of soil fertility	*1. Replacement cost*
		2. CVM
	storage)	1. PES scheme (CO2 price in EU ETS)
		2. CVM
	Natural pest control	*n/a*
Cultural services	recreation	1. Resource rent method
		2. Expenditure based method (cost based approach) (trans-ecosystems)
		3. Time use based approach (trans-ecosystem)
		4. CVM
		5. Travel cost method
	Hunting	1. Consumer expenditure, benefit transfer
	Environmental education	1. Expenditure transfer approach (trans-ecosystem)
		2. Expenditure based approach (trans-ecosystem)
		3. Time use based approach (trans-ecosystem)
		4.Travel cost approach
		5. CVM
	inspiration for culture, art and	*1. CVM*
		2. Expenditure based method (costs to restore semi-natural grasslands)
		3. Direct market price
		4. Hedonic pricing method
		5. Benefit transfer
	Spiritual experience and sense of place	*1. Expenditure based method (costs to restore semi-natural grasslands)*
		2. CVM

Ecosystem service of maintenance of the soil quality was another candidate but not chosen for the valuation this year. We were interested in evaluating this service but we were not quite sure about how to approach this? Experts noted that as it is largely a supportive intermediate service for a number of different services, including flood protection, but also agricultural production and water supply. And as it was doubted by the experts on how much attention to put on it compared to final services in a first round of the service, it was decided not to focus on this service.

Based on expert consultations before the start of the project and during the project we understood that in initial phases of the UN SEEA EEA application (where Estonia currently is) the valuation more complicated ecosystem services would require a lot of modelling. We have been suggested by the experts (UK) that for the several of the ecosystem services that requires modelling the plans for the valuations should be made for the next periods. The plans were set up for next periods to capture also flood protection later due to the same reasons as mentioned above, the lack of basic data.

We discussed how to valuate recreation/tourism, nature education and aesthetic, inspirational services and that we would be rather limited in our focus on agricultural and semi-natural grasslands. Regarding the cultural services it became clear that we cannot separate only grasslands when valuating many of those services. We questioned if we might bring out the grasslands contribution to tourism or should we look at it more broadly? Experts (UK) suggested to carry out the valuation of the service over all the ecosystems. So with recreation approach was taken to cover the bigger picture and then give proportions using some bottom up information from surveys or map.

Discussions with more experienced experts from statistics Netherlands and UK were of utmost importance. There were 4 longer SKYPE or telecons arranged and the methods were discussed. UK experts suggested us to try to evaluate in more detail nature education service evaluation methods e.g. to focus at least on one of the service that has not been analysed or looked into in depth by statistical community.

Lot of expectations were for the deliveries of the ELME project but unfortunately the timing of the actions for this project was too late for us in sense of harmonizing the definition of the services and methods.

Methods were further discussed on a study visit and later were further elaborated and discussed with project group.

It is worthy of mentioning that as Statistics Estonia did not receive initially planned input from the ELME project and indirect methods and approaches were used to get the data needed for the work. However, the information that the ELME project collects and will process would be of good quality and when these data will become available it would be certainly used in order to assess the monetary value of ecosystem services. In the next phase of the development of ecosystem accounts, it is likely that the results of the ELME project could already be available. At the moment they have produced maps of forest ecosystems, formulated principles for forest ecosystem assessment and assigned status classes, and compiled lists of ecosystem services. During the remaining time of the project, ELME team evaluates the quality and quantity of all services and draw up service volume maps.

Final seminar discussed the applied methods, results derived and identified the issues for the future development. Next year grant will focus on wider range of services and other types of ecosystems.

Next chapters provide an insight to the methods applied for the valuation of the services, related discussions and decisions.

3.3 Methods and valuation of services

Methods for monetary valuation of the grassland ecosystem services in Estonia were tested and monetary values using selected methods were calculated for 2018 (for some services the last available years data had to be selected).

It was projected in grant proposal that from ecosystem provisioning services hay, fodder, meat, wool, medicines and herbs and from regulating services carbon sequestration and habitat provision would most probably be monetized and that regarding cultural and regulating services the valuations would probably be based on the investigations made by the experts involved in the project. Eventually eight ecosystem services were chosen for monetary assessment. Several of those were valued by alternative methods. Additionally the ecosystem service of provisioning of the habitats for species was discussed just theoretically.

The suggestion to focus on and to carry out a more in depth research regarding nature education as an ecosystem service was given by one of the project advisers (DEFRA, Rocky Harris). Concepts were analysed, definition of the service was agreed and valuation and integration of the nature education ecosystem service was carried out. As a result of this experimental work the assessment of the service and the proposed methodology are described in current report. Methodology was also presented to the London Group on Environmental Accounting for discussion. The discussion was followed by the more in-depth discussions with the revisers of the UN SEEA EEA handbook as several of the issues which we tackled are important from the revision process as well, for example: how to find the share of the contribution of ecosystem from the total service value, which expenditures to include if basing the valuations on expenditures in some way, which indicators of condition would be relevant for assessing the continuing capacity of the ecosystem to supply nature education services, importance of the determining of the ecosystem service supplying areas both in the context of the single services macro assessments or the assessments of relative importance of a particular ecosystem and ecosystem type[32].

Overview table was provided integrating ecosystem services absolute and per ha values calculated by alternative methods by ecosystem types.

Current work this year focuses on grasslands ecosystem services valuation. But as we started to carry out the valuation of the ecosystem services for this ecosystem type we realized that just some services belong to only one ecosystem (like fodder is specific for grasslands). In several cases we handled several services across the ecosystems and then in later stages broke it down appropriately between ecosystem types.

[32] 25th Meeting of the London Group on Environmental Accounting 7-10 October 2019, Melbourne. https://seea.un.org/sites/seea.un.org/files/lg_article_nature_education_as_ecosystem_service_estonia_03_oct.pdf. Personal communication with Carl Obst and methodological discussions with Sjoerd Schenau and Rocky Harris.

3.3.1 Fodder production

Fodder production is a provisioning service that is used to feed livestock to produce milk, meat and other products.

3.3.1.1 Definition of the ecosystem service

The ecosystem service is providing fodder for feeding livestock. It is defined as the contribution of fodder by ecosystem asset (grasslands) to the production of livestock by agriculture sector. The economic benefit is the value of fodder after harvest. The benefits are the result of the combined input of ecosystem services, produced capital and human capital. The beneficiaries are farmers that grow livestock and use fodder gathered from grasslands to feed the animals.

3.3.1.2 Methods and data

Fodder is a market good and therefore can be calculated using market-based methods and exchange values.

The market-based methods - rent prices, resource rent, market price approaches and hybrid method of market price and resource rent were tested in order to calculate fodder production for all Estonian grasslands. Data from agricultural statistics, national accounts, Material Flow Account (MFA) and some others were used.

3.3.1.3 Rent price method

3.3.1.3.1 Methodology

Rent is an expenditure that user pays to the owner to use the resource. Rent payments can be related to the provision of fodder service provided by ecosystem as the renter is willing to pay the rent to use the service. In order to calculate the value of fodder production service average rent prices were multiplied with the extent of grasslands where the fodder is collected. Extent data of area under cultivation and rent prices were available from agriculture statistics. In Estonia average rent price and extent data are available on a county level and therefore it was possible to evaluate the supply of fodder service with rent price approach for all 15 counties separately. Average rental cost of arable land was used for short term grasslands and rent of permanent grasslands was used for extent of semi-natural and permanent grasslands.

This method estimates the potential of fodder supply as it calculates the value if all cultivated grasslands are rented to users.

3.3.1.3.2 *Results*

The highest (77 €) rent of permanent grasslands was in Ida-Virumaa county and the highest (79) rent of arable lands was in Valgamaa county. The lowest values were accordingly in Hiiumaa (33 €) and Pärnumaa counties (43), the difference of lowest and highest regions were accordingly 44 and 36 €, which are lower than country's average price (50 and 62 €). According to the calculations the highest (3.2 million €) fodder production value was produced in Pärnumaa because of the largest extent and average rent price. The calculations include all grasslands - semi-natural, permanent and short-term grasslands. Rent prices were not available for all the counties. Country's average rent prices (50 and 62) were used for counties that did not have available rent price. Total supply of fodder production service using rent price method was 26.0 million € in 2018. Total supply of fodder produced in short-term grasslands was 11.2 million €. Source data and values of the calculations can be seen in Table 9. Compared to permanent and semi-natural grasslands the value of short-term grasslands that are rather treated as agricultural field, is much lower. Lower value is due to difference in the extent of land.

Table 9. Rent price, extent and production of fodder from permanent and short-term grasslands by counties, 2018

	Rent price per hectare, €		Extent data, hectare			Supply, million €			
	Permanent grasslands	Arable land	Semi-natural grassland	Permanent grassland	Short-term grassland	Semi-natural grassland	Permanent grassland	Supply of semi-natural and permanent grasslands, million €	Supply of short-term grasslands, million €
Total	**50**	**62**	**234 704**	**263 817**	**174 446**	**12.2**	**13.8**	**26.0**	**11.2**
Harjumaa	50	58	29 006	28 074	10 911	1.5	1.4	2.9	0.6
Hiiumaa	33	..	8 973	8 834	1 420	0.3	0.3	0.6	0.1
Ida-Virumaa	77	..	10 015	7 291	5 524	0.8	0.6	1.3	0.3
Jõgevamaa	..	..	9 772	11 498	20 600	0.5	0.6	1.1	1.3
Järvamaa	69	77	7 247	13 019	10 404	0.5	0.9	1.4	0.8
Läänemaa	..	..	16 736	13 218	4 439	0.8	0.7	1.5	0.3
Lääne-Virumaa	52	..	17 104	19 509	18 741	0.9	1.0	1.9	1.2
Põlvamaa	56	70	8 221	6 068	23 547	0.5	0.3	0.8	1.6
Pärnumaa	..	43	31 393	33 568	10 062	1.6	1.7	3.2	0.4
Raplamaa	56	52	2 745	27 010	13 815	0.2	1.5	1.7	0.7
Saaremaa	48	56	34 097	33 220	5 620	1.6	1.6	3.2	0.3
Tartumaa	..	77	19 699	14 567	14 980	1.0	0.7	1.7	1.2
Valgamaa	54	57	10 470	13 975	7 494	0.6	0.8	1.3	0.4
Viljandimaa	57	79	14 734	15 644	15 139	0.8	0.9	1.7	1.2
Võrumaa	..	..	14 492	18 323	11 751	0.7	0.9	1.6	0.7

.. – not available

Agricultural statistics have data for temporary and permanent grasslands which include also semi-natural grasslands. Grazing in semi-natural grasslands is subsidised by the government therefore grazing should be distinguished from short-term grasslands and not summed up as is in agricultural extent data. This problem was solved by using data from ecosystem extent account

This method and results were also introduced to our colleagues in agricultural statistics but they did not approve it as the fodder value should contain more expenditures and not just rent price which should be considered as only one component of farmer's expenditures when producing fodder from grasslands. Colleagues from Statistics Netherlands still considered this method to be a good approximation for the price of the ecosystem service provided by land owned by farmers. The rent can be considered as a residual item that can be attributed to ecosystem as it is an agreement between the owner and the renter and therefore shows the willingness to pay to use the service.

3.3.1.3.3 Analysis

Rent price as the name implies, is based on the lessee's willingness to pay the rent. Applicability of the method requires lots of rental deals and good statistics on rent prices. Practical use of rent method based on the thought construct, that all grasslands are rented to users.

The strength of the method is that it reflects the value of the ecosystem (grassland) itself as a provider of fodder and does not depend on the use of grassland (mowing or grazing), the type of grassland (cultural or semi-natural) and the crop cultivated. Unlike the resource lease method, the rental price method is straightforward and does not require sophisticated formula and complicated statistics. The biggest disadvantage of the method (according to statisticians) is that it estimates the potential of the ecosystem service and not the actual fodder output.

The methodological question for the rent price method is whether the total rent price is attributable to the ecosystem and treated as an ecosystem value. According to accounting logic, the rent price margin should be deducted from the ecosystem service. But how to do it in practice? Issues were discussed also on a seminar and the open questions were addressed in the "List of the issues for future discussion …" section of this methodological report.

3.3.1.4 Resource rent method

3.3.1.4.1 Methodology

Resource rent was calculated using data from national accounts in following formula:

Output
Less intermediate consumption
Less compensation of employees
Less other taxes on production
Plus other subsidies on production
Equals Gross operating surplus
Less consumption of fixed capital (depreciation)
Less return to produced assets
Less labor of self-employed persons
Equals Resource rent

Resource rent method is used for calculating ecosystem service value by subtracting all costs for capital and labour from the total revenue. The residual value is attributed as the ecosystem contribution.

Data in national accounts are quite aggregated and only total data of NACE 01 – Crop and animal production, hunting and related service activities were available. Using financial data from agricultural statistics, it was possible to distinguish separately crop production, animal production and hunting and related service activities. Distinction of fodder from total crop production was made using shares from agricultural statistics.

Return to produced assets was not readily available from national accounts production accounts team and had to be calculated separately according to formula in the manual of SNA on capital production account. Statistics Netherlands suggested to use 2% of the asset value in order to estimate the return to produced assets. Total asset value of NACE 01 was available from national accounts. First the share of fodder was used to distinguish fodder from total NACE 01 and then 2% was used to calculate the return to the produced assets. Also labour of self-employed persons had to be calculated as these are not recorded under the compensation of employees. The income of self-employed was calculated using data on the average wages in NACE A and the employment (in fte) of self-employed people.

This method gives the results of actual supply of fodder traded on the market and is also included in national accounts.

3.3.1.4.2 Results

First the total production data had to be distributed to crop production, animal production and hunting and related service activities, it was done using shares from microdata that were multiplied with total NACE A.01. Then the resource rent of total crop production was calculated using the formula. Resource rent of crop production was 26 million € in 2018. The share of fodder in total crop production in monetary units was calculated using monetary data from agriculture statistics and it was 18% in 2018. Using this share, the resource rent for fodder was estimated to be 4.7 million € in 2018. Resource rent value is very dependent on shares and assumptions (e.g. labour of self-employed people). Results and components of resource rent approach can be seen in Table 10.

Table 10. Resource rent of fodder, 2018, million €

	Crop production (million €)
Output of crop production (NACE A 01.1 - A01.1.3)	341
Intermediate consumption (NACE A 01.1 - A01.1.3)	239
Compensation of employees	66
Other taxes on production	1
Other subsidies on production	-86
Consumption of fixed capital	55
Return to produced assets	11
Labour of self-employed persons	29
Resource rent (NACE A 01.1 - A01.3)	**26**
Resource rent of fodder	**5**

3.3.1.4.3 Analysis of resource rent method results

The resource rent method is based on the market price of agricultural production (fodder) from grassland. The nature of resource rent is calculating ecosystem service value by subtracting all costs for capital and labour from the total revenue. Of the three methods used, this is the most complicated because it requires a large number of statistical data organised in sophisticated way. Official statistics are too aggregated compared to what a resource rent method would require.

The universal disadvantage of production cost-based methods is that the production (grass), which cattle consumes in situ, is not adequately reflected in the statistics and can easily be left out of the value calculation. One of the disadvantages of using the resource rent method is, that agricultural statistics do not generally distinguish between production from semi-natural and cultivated grassland. However, this is not a problem specific to the method.

The undisputed strength of the resource rent method over other methods is that the role of the ecosystem in value creation is well established and can be adequately evaluated. This is crucial for determining the true value of fodder production as an ecosystem service.

In general, regarding resource rent method, it can be argued that, despite the disadvantages described above, this method, at least for grasslands where fodder output is primary agricultural production (e.g. hay), gives the most accurate result.

The main obstacle to the practical application of the method is the plurality of needed data and the lack of appropriate statistics.

3.3.1.5 Market price approaches

As fodder is a market good that has an actual price, another attempt was made to calculate the value of fodder production service of grasslands with market price approach. For market price method the amount and price data are necessary. In this project two types of amounts and prices were tested – one with data from agriculture statistics and the other with data from the Material Flow Account (MFA).

3.3.1.5.1 Methodology based on agriculture statistics data

For this method fodder production data and price data from agricultural statistics were used. In order to estimate the total value of fodder produced, the quantity of produced fodder from grasslands was multiplied with price for a ton of forage. Agricultural statistics calculates routinely production of all fodder. The production data and information on purpose are gathered with survey. Results are afterwards included to economical calculations that is also used in national accounts. Loss and grazing is left out and not added in the calculations as these are not traded on the market but the data were available to use in this study. Agricultural statistics use price that is calculated using price indexes and is for fodder together (includes hay, silo and straw).

In order to estimate the production from grasslands the fodder gathered from other places than grasslands were first subtracted from total fodder production.

In order to derive the ecosystem service value for fodder as the market price reflects the value of the benefit and not the ecosystem service[33] the expenditures were subtracted from the value of the benefit. The residual item could then be attributed to ecosystems. Share of expenditures from production was available from the Farm Accountancy Data Network (FADN) report for the year 2017.

In agriculture economical accounting only fodder that was traded on market is included. Therefore fodder that has been consumed on the field is not included in agriculture accounting nor in national accounts. Its economic value is zero although its physical value is higher than zero. In order to estimate the potential value of consumed fodder also the value of fodder eaten on the field was evaluated in this study.

The market price approach estimates the actual supply of fodder but it gives also opportunity to calculate the potential supply by using the same market price for all consumed fodder.

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[33] UN (2017) SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft. New York, USA. Page 107, Chapter 6.39.
https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

3.3.1.5.2 Results based on agriculture statistics data

According to the data from agriculture statistics first the actual (included in national accounts) supply was found. The average price for a ton of fodder was 27.8 € in 2018. Total production of fodder (1.9 million tons) was multiplied with the price. Fodder service value was 52.8 million € in 2018. To estimate the ecosystem contribution share of expenditures from output of an average dairy farm was used. The share was available from FADN for the year 2017 (87%). The average share from 2017 was used to estimate the value for 2018 data. Using the share the ecosystem contribution was calculated to be 6.9 million €.

This method can be considered as the most compliant with agriculture accounting compared to other used approaches. Agriculture account data is also used in national accounts which makes the results easily comparable with SNA data.

Service supply is probably higher than data of agriculture statistics currently cover. The amount of fodder that was consumed by livestock in situ was available from agricultural statistics. The value of fodder that was consumed could be calculated by adding the in situ eaten amount to actually traded fodder and multiplying it with the price of fodder. The yield of fodder that was consumed on the field was 611 thousand tons in 2018. The value of traded and eaten fodder from grasslands in 2018 was estimated to be 69.8 million € and the ecosystem contribution was estimated to be 9.1 million €.

The weakest part is probably the share of expenditures in the market value. In this study FADN data from year 2017 of a dairy farm were used but it might not reflect expenditure structure of a fodder producing farm. Also return to produced assets and unemployed employees should be added in addition to expenditures. Then the residual item that could be attributed to ecosystems would be smaller.

3.3.1.5.3 Methodology based on material flow accounts (MFA) logic

Another market price approach was tested using physical data from MFA. Physical amounts of consumed fodder by livestock were available from MFA. For MFA calculations the number of livestock and their yearly consumption of fodder by species are considered. In order to estimate consumed fodder from grasslands extent data is used in MFA. This approach gives the actual supply of fodder.

For calculating the value of fodder service the amount of fodder consumed by livestock available from MFA was multiplied with the consumer price of dry weight fodder.

In order to calculate the contribution of ecosystem, which is the residual after intermediate costs are subtracted, share of expenditures from production that was available from the FADN report for the year 2017 was used.

The method for estimation of grazed biomass for MFA purposes was worked out during project conducted in Statistics Estonia. Quantity of grazed biomass calculated with the help of built-in calculation tool for gazed biomass from Eurostat’s MFA Questionnaire was compared with data from agricultural statistics about grazed biomass (available only for years 2003-2008).

The comparisons of statistical data and data estimated by Eurostat's estimation tool about gazed biomass indicates, that estimations are systematically bigger. There could be two reasons for this difference. From the one side, geographical conditions in Estonia is not as favourable for biomass growth as in Middle and South Europe; and from other side, grazing period is shorter. Using the estimation tools included to MFA questionnaire cause overestimation in Estonian case. Average share of overestimations for years 2003-2008 made up 44%. As statistical data about gazed biomass were not available since 2009 the estimations of quantity of grazed biomass for MFA purposes were made by estimation tools of MFA questionnaire was adjusted with average share of overestimations for years 2003-2008 (44%).

Data about gazed biomass for MFA are calculated in dry mater.

3.3.1.5.4 Results based on MFA methodology

The amount of gazed biomass (consumed amount of fodder) in material flow account was 364 thousand tons in 2018 (in dry weight). This is considered as amount of fodder consumed by livestock in 2018.

According to the Agricultural Research Centre producing price of 1 ton of dry weight fodder was 89 €/tons. In order to get the consumer price it is necessary to add also profit of the producer and value added tax. Addition of these figures expand the price ca 30%. By multiplying the amount with estimated price of dry forage which was 108 €/ton in 2018 we get the value of fodder that was eaten by livestock. Fodder service in 2018 was 39 million €. To calculate the value of ecosystem contribution the share of profit from output of an average dairy farm was used. The share was available from FADN for 2017 latest (13%). The average share from 2017 was used to estimate the value for 2018 data. Using the share the ecosystem contribution was calculated to be 5 million €.

The weakest part of this method might be the quality of the price data. Producer price for producing dry fodder from cultural meadows available from the Agricultural Research Centre for the year 2018 was used.

The results and basic data of market price based methods are seen in Table 11.

Table 11. Results of market price based methods, 2018

Method	Quantity, mln tons*	Price, €/tons	Fodder production	Ecosystem contribution
Using data from agriculture statistics (included in national accounts)	1.9	27.8	52.8	6.9
Using data from agriculture statistics (partly included in national accounts)	2.5	27.8	69.8	9.1
Using data from MFA	0.4	108	39.3	5.1

*has to be considered that MFA data are in dry weight, data from agricultural statistics are not

3.3.1.5.5 Analysis of the results based on various market price methodologies

Market price method is widely used in the valuation of market value production-related ecosystem services.

This method, based on the market price of ecosystem production (fodder), is less complicated than resource rent. However, this method has all the disadvantages inherent for resource rent method, except for the need for complex data. The method makes it difficult to differentiate production from cultural grassland and semi-natural grassland. Likewise, there is a risk of losing in accounting the fodder (grass) consummated by cattle in situ.

However, this method lacks the main advantage of resource rent, which is to differentiation of the contribution of the ecosystem from the market price of production.

Although the accuracy of the market price method and the extent of its use are limited in the estimation of ecosystem fodder production value, the method is easy to use because it is based directly on market prices.

In order to calculate the contribution of ecosystem also return on produced assets and unpaid labour should be deducted from expenditures. As sufficiently detailed data was not available these items were not able to subtract.

3.3.1.6 Hybrid approach

3.3.1.6.1 Methodology and results

Another attempt was made to use a method that would be a combination of resource rent and market price methods. First the fodder output with the market price method was calculated. Then the share of fodder output from total of NACE 01 – Crop and animal production, hunting and related service activities was estimated (8%). Using the share and expenditure structure from national accounts (described under resource rent approach paragraph) the resource rent method for fodder was calculated (5.3 million €). The results can be seen in Table 12.

Table 12. Hybrid method of market price and resource rent of fodder, million €, 2018

	Fodder production (million €)
Output of fodder production	70
Intermediate consumption	49
Compensation of employees	13
Other taxes on production	0
Other subsidies on production	-18
Consumption of fixed capital	11
Return to produced assets	2
Labour of self-employed persons	6
Resource rent	**5**

The total output of fodder calculated in this method includes also fodder that was consumed by livestock in situ although it is not included to NACE 01 in national accounts. An assumption was used that the fodder consumed in situ can be handled in the resource rent formula similarly as fodder traded on the market. This ecosystem contribution is not totally included in national accounts as the fodder that has been eaten by livestock on the field is not added to economic calculations. The fodder consumed by livestock in situ was added in this study as the fodder was supplied by grasslands and used by livestock.

The difference between resource rent and hybrid method is that in hybrid method the output is calculated using the market price and the variables of resource rent were calculated using the structure of expenditures from the national accounts.

3.3.1.7 Conclusion of evaluation of fodder production service

Four different valuation approaches for calculating fodder production service value were tested. Results of the approaches can be seen in Table 13. Also ecosystem contribution was estimated.

Table 13. Values of fodder supply ecosystem service and ecosystem contribution by estimation approaches, million €, 2018

Valuation method	Value of the fodder production service	Value of ecosystem contribution
Rent price		26.0
Resource rent		4.7
Market price - agriculture	69.8	9.1
Market price - MFA	39.3	5.1
Hybrid	69.8	5.3

Result of the rent price approach is quite different while the results of resource rent, market price ad hybrid approaches have similar magnitude.

The result of rent price approach may be too high compared to the results of other approaches as rent price might be overestimated as many of the rents might be agreed verbally and are not recorded anywhere. Suggestion was made that profit margins should be deducted from the total rent value.

The weakest part of the market price approach that use MFA data might be the quality of price data.

Results of agriculture statistics based market price approach can be considered as one of the most realistic approaches as it includes transactions that are already recorded in agricultural and national accounts. The calculations were also discussed with colleagues from agriculture statistics. In order to estimate the ecosystem contribution share of expenditures from total production from 2017 were used by assuming that the share was the same also in 2018. Still the used expenditure structure might not reflect the actual situation of fodder production farm as it was based on a dairy farm. Therefore the share of residual attributed to ecosystems might be under or overestimated.

By analysing the results it seems that the resource rent is also a good approach to estimate the value of fodder production service. Still it has to be considered that it is also very dependent on assumptions. Some of the formula components are not readily available (e.g. return to produced assets and labour of self-employed persons) and have to be separately estimated.

Attempt was made to combine the resource rent and market price methods in a hybrid method that include variables from both methods. It seems that the results of this method would reflect the ecosystem contribution the best compared to other tested methods. Therefore, 5 million € calculated as ecosystem contribution of fodder production in 2018 was selected from the methods to show the ecosystem contribution value.

Statistics Netherlands suggested to use rent price method as it is not yet decided witch value should be attributed to ecosystems – the whole value of a service or a residual item. Also resource rent method includes many assumptions and is not as straight forward as rent price method.

Another aspect is that it is difficult to choose the best approach by analysing results of only one year. Analysis of time series might give important information and would give opportunity to see how the results of these approaches would change over time.

The methods used in this study were also evaluated according to various criteria's that can be seen in Table 14.

Table 14. Evaluation of used methods to calculate the value of fodder production

	Rent price	Resource rent	Market price - agriculture	Market price - MFA	Hybrid market price method approach
Aggregated (official) statistics is sufficient and available	No	No	No	No	Yes
Need for complicated statistics	No	Yes	No	No	Yes
It is well connected to spatial data	Yes	No	No	No	No
Takes into account differences in ecosystems (cultural-semi-natural)	No	No	No	No	No
Takes into account the grass fed by the cattle in situ	No	No	Possible to take into account	Yes	Possible to take into account
Distinguishes the role of the ecosystem in the price of production	Yes	Theoretically yes	Theoretically yes	Theoretically yes	Yes

Both the resource rent and rent price methods were considered to be correct methods by the project experts but resource rent weakness is the use of several assumptions and therefore rent price was considered more straightforward. Overall resource rent is not as trustworthy as there are currently no good quality data available.

3.3.1.8 Spatial distribution of fodder production service

One of the goals of this study was to analyse the difference in supply of ecosystem services between grassland types. Two main types of grasslands are cultural and (semi) natural grasslands. Under cultural grasslands category short-term grasslands, which belong to agricultural land category, are considered in addition to permanent grasslands. In order to make the distinction, yield data of these grassland types were analysed. According to the Agricultural Research Centre yield of permanent grasslands is 25% higher than in semi-natural grasslands. According to the data of 2018 year yield of short-term grasslands was twice bigger than of permanent grasslands. Using the shares the total ecosystem contribution calculated with hybrid method for fodder production was divided. With the hybrid method 3.3 million € came from short-term grasslands, 1.6 million € from permanent grasslands and 0.4 million € from semi-natural grasslands. For the rent price method the value was already calculated by grassland type and according to that 11.2 million € came from short-term grasslands, 21 from permanent and 5.2 million € from semi-natural grasslands from fodder production service. Only the value of semi-natural and permanent grasslands were included in supply and use table as short-term grassland is considered as agriculture land. Table 15 displays the yields and results.

Table 15. Yields and value of fodder, 2018

	Yield, t/ha per year	Share, %	Hybrid method - value, million €	Rent price method - value, million €
Semi-natural grassland	3	0.10	0.4	5.2
Short-term grassland	24	0.48	3.3	11.2
Permanent grassland	12	0.42	1.6	20.8

Visualization of the service provisioning areas (grasslands excluding short-term grasslands) and values of provisioning fodder of Estonian grasslands is shown in Figure 3.

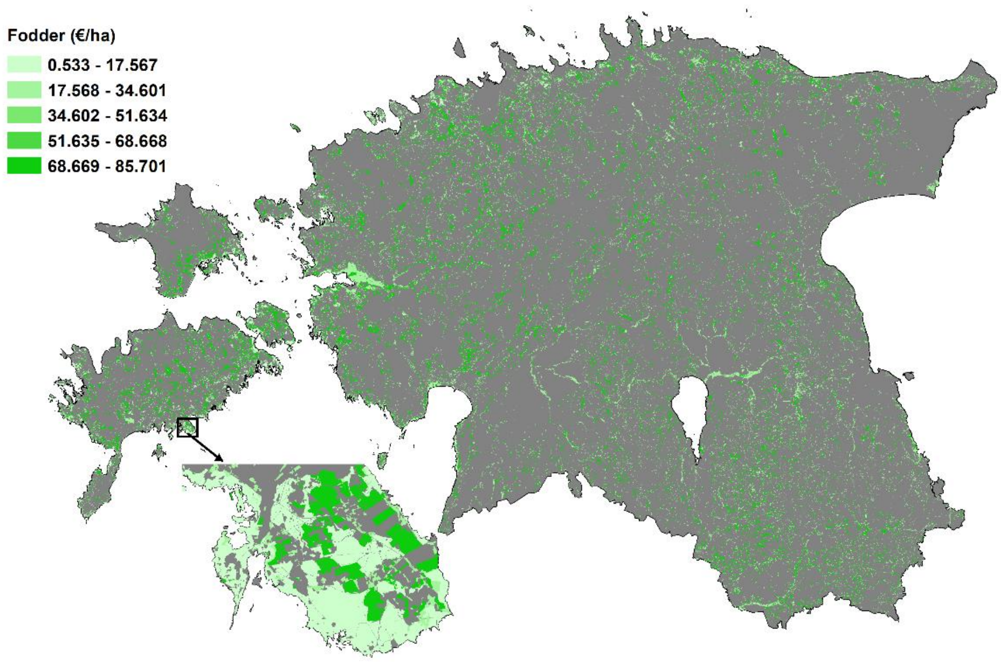

Figure 3. The ecosystem service provisioning areas and values of provisioning fodder at Estonian grasslands. The areas coloured in shades of green represent grasslands (excluded short-grasslands) according to the value they supply the service that was calculated using rent price method. The values shown correspond to the total value of ecosystem service per grassland type. Dark grey areas are other ecosystem types that were not analysed in the current work.

3.3.2 Biomass from non-agricultural sources (Raw materials, biomass for bioenergy)

Semi-natural grasslands provide biomass which can be used for producing energy. The current use of biomass from grasslands for producing energy is low in Estonia which means that the real flow of the ecosystem service of grasslands to provide biomass which is being used in energy production and enters the economy is also low.

However there is a considerable potential of grassland ecosystems to provide biomass therefore there is also a potential for the bioenergy sector to increase when the potential supply is used as whole. There is an estimation that up to 60 000 ha[34] of semi-natural grasslands needs to be maintained in Estonia but currently about 34 000 hectares[35] of semi-natural grasslands are only maintained.

There is an estimation that without alternative uses of biomass and other obstacles like technical issues, 2% of Estonian primary energy consumption could be replaced by bioenergy that comes from semi-natural habitats[36]. Floodplain meadows have the highest potential among different grassland types in that regard where annual average dry biomass yield per hectare is 5.7 tonnes, while the same indicator from wooded meadows is 1.6.

3.3.2.1 Definition of the ecosystem service

According to CICES v5.1 the ecosystem service of providing biomass for producing energy is described as plant materials used as a source of energy (Table 16). Here it is defined as the contribution of biomass by ecosystem asset (grassland) to the production of energy by energy sector. The economic benefit is the value of the biomass after harvest, i.e. the value of the produced grass, or the value added in energy sector. The benefits are the result of the combined input of ecosystem service, goods and services, produced- and human capital. The beneficiaries are the heat production plants that use biomass as a fuel.

Table 16. Definition of the ecosystem service of biomass used for energy production according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy	1.1.5.3	Materials from wild plants, fungi and algae used for energy	Parts of the standing biomass of a non-cultivated plant, fungi, algae or bacteria species…	…that can be harvested and used as and energy source	"Volume of harvested wood "	Fuel wood
Cultivated plants (including fungi, algae) grown as a source of energy	1.1.1.3	*Plant materials used as a source of energy*	*The ecological contribution to the growth of cultivated crops…..*	*…that can be harvested and used as a source of biomass-based energy*	*Standing crop of Miscanthus at time of harvest*	*Energy production*

3.3.2.2 Methods and data

Name of the dataset	Data type	Source
1251 - Consumption of fuels and energy 2017	Statistics	Statistics Estonia
Ecosystem unit map	Spatial data	Statistics Estonia

[34] Poolloodusllike koosluste tegevuskava aastateks 2014-2020 https://www.envir.ee/sites/default/files/plk_tegevuskava2016.pdf
[35] Keskkonnaamet. Kuidas hooldada ja taastada poolloodusllikke kooslusi. https://www.looduskalender.ee/n/node/3404
[36] Lepasaar, Helli & Ehrlich, Üllas. (2015). Non-market value of Estonian semi-natural grasslands: a contingent valuation study. Eesti poolloodusliku rohumaa turuväline väärtus: tingliku hindamise uuring. Discussions on Estonian Economic Policy. 23. 10.15157/tpep.v23i2.12494.

We found that the market price of harvested hay/grass with the purpose to be used as fuel is the best estimation of the value of the ecosystem service.

For valuing the service the data about the quantity and purchase prices of fuels recorded in energy statistics were used. The companies which used hay/grass as a fuel were determined and the purchase prices they had paid for the fuel were added. Prices without VAT were used in calculations to decrease the amount of human input. No further deductions of other human inputs were made.

Another possible method is to look at gross (or net) value added generated by economic activities that depend upon natural capital. In this case it is the heat production plants that require grass as fuel. Gross value added (GVA) is the value of economic output minus the costs of intermediate inputs. Net value added (NVA) is gross value added minus the consumption of fixed capital (depreciation). NVA and GVA both reflect the combined return on capital, labour and natural capital, for instance in a country or in a sector. The value of GVA is already incorporated in GDP in NA. It describes how important the ecosystem service is and the contribution of the ecosystem to the economy.

3.3.2.3 Results of market prices method, 2017

Currently only one company, Lihula boiler house, produces heat from biomass harvested from semi-natural grasslands in Estonia. Hence, the monetary value of the biomass used for energy production has been calculated based on the use of biomass (hay/grass) from semi-natural grasslands of Matsalu National Park (floodplain meadows) as fuel for Lihula boiler house. According to the market price the value of the service of providing biomass for producing energy was 50 747 € (without VAT) in 2017.

1.1.1.1 Results of the GVA method, 2017

When using the gross-value added (GVA) method the contribution of the ecosystem to the energy sector was 46 082 € in 2017.

Economic output	206891
Intermediate costs	50747
Labour costs	43 085
Depreciation of fixed capital	66977
GVA (€)	46082

3.3.2.4 Spatial analysis

Knowing that the biomass valued on the assessment is from semi-natural grasslands of Matsalu National Park (floodplain meadows) we attributed the value to the ecosystem type class Northern Boreal alluvial meadows (Natura 2000 habitat code: 6450) in the region with an area of 5162.93 ha. It gave us the value 9.83 €/ha for the service provisioning area. According to GVA method the contribution of the ecosystem per hectare in the service provisioning area was estimated as 8.93 €/ha.

Visualization of the service provisioning areas and value of bioenergy ecosystem service of Estonian grasslands can be seen in Figure 4.

Figure 4. The ecosystem service provisioning areas and value of provisioning raw material for bioenergy of Estonian grasslands. The areas coloured in the scale from brown to green represent grasslands according to the value they supply the service that was calculated using market price approach. The values shown correspond to the total value of ecosystem service per grassland type. Grey areas are other ecosystem types that were not analysed in the current work.

3.3.2.5 Conclusion

The results of the two methods used to assess the provisioning of biomass for bioenergy ecosystem service , market price and GVA were fairly similar, around 0.5 million € per year. Although the results are similar, the market price method is easier to apply and requires less input data. Therefore we prefer using the market price method.

The potential supply and actual supply of the service are very different as biomass from semi-natural grasslands, including flooded meadows is largely used for grazing or is not used in economy at all. The volumes of biomass entering the economy as a raw material for energy production is relatively low, only 0.5 million € according to market price method.

In Estonia only Lihula boiler house uses biomass for energy production. The boiler house uses so-called 1st generation technology, i.e. biomass is burned. It is very difficult to obtain hay suitable for this technology as a by-product of the maintenance of semi-natural grasslands, since mowing will not begin until the second half of July. Late mowing creates situation where the collected hay has high moisture content and low calorific value. Such hay cannot be used in the boiler house.[37] From the boiler house

[37] Interview with Tõnu Teesaar, the chairman of Lihula Soojus, 28.10.2019

point of view, the hay would be more usable if its moisture content would meet the requirements of technology. As a result, very small amount of biomass is actually burnt in Estonia. Therefore, the monetary value of biomass for energy is also calculated as relatively low. Nowadays, technology for the production of 2nd generation biofuel or bioethanol has been developed based on hydrolysis and fermentation of biomass.[38] The application of this technology will enable the utilization of all biomass resulting from the management of semi-natural grasslands. Having information of the production potential of semi-natural grasslands in light of 2nd generation biofuels, it would be possible to estimate the potential monetary value of biomass that could be used for energy production.

3.3.3 Provisioning of game/hunting

The ecosystem service is providing wild game (hereinafter *game*). The ecosystem service of provisioning of game is closely related to hunting as the first is a prerequisite for the latter. Providing game (in sense of game meat) is considered as a provisioning ecosystem service whereas hunting is considered as a recreational activity under cultural ecosystem services. People are involved in hunting for both purposes and these often overlap. Therefore it is difficult to determine under which category the service of provisioning of game/hunting falls or how to divide it into shares.

In the development of suitable methods to assess the value of the ecosystem service of provisioning of game/hunting we consider two approaches: first, provisioning of game as a provisioning service and secondly hunting as a cultural service which is included in the assessment of recreational ecosystem service. The two approaches characterize two different aspects that the asset provides, and use different data as an input, therefore it is possible to add up the provisioning and recreational value of game/hunting when overlapping part is distinguished.

3.3.3.1 Definition of the ecosystem provisioning service

According to CICES v5.1 the ecosystem service of providing game is described as wild animals (terrestrial and aquatic) used for nutritional purposes (Table 17). The ecosystem provisioning service of providing game is defined as the provisioning of elements needed for the growth and livelihood of game (food, water and habitat) by ecosystem asset. The economic benefit is the meat from wild game. The beneficiaries and users of the service are meat processing companies that use the game as the input to their production.

Table 17. Definition of the ecosystem service of provisioning game according to CICES v5.1

Class	**Code**	**Simple descriptor**	**Ecological clause**	**Use clause**	**Example Service**
Wild animals (terrestrial and aquatic) used for nutritional purposes	1.1.6.1	*Food from wild animals*	*Non-domesticated, wild animal species and their outputs…*	*…that can be used as raw material for the production of food*	*Harvestable surplus of cod population, or deer population*

[38] T. Kikas „Biokütused Maaülikooli Tehnikainstituudis“ Ettekanne.

3.3.3.2 Methods and data

People in Estonia go hunting to obtain game for their own use or sell it to meat processing companies who sell the products made out of it. As game is traded in the functioning market, it gives the reason to use the market prices to value the service. Only some of the big game: elk, red deer, roe deer, wild boar, and brown bear have commercial importance in that approach. Skins of elk and red deer are traded in small quantities. Because of the lack of demand, skins of small game are not traded in the market.

Name of the dataset	**Data type**	**Source**
Hunted game 2018/19	Statistics	Estonian Environment Agency
Weight of game's cold body	Literature, expert consultation	Randveer, T. (2003)[39]
-	Purchase prices in 2019	Meat processing companies
Ecosystem unit map	Spatial data	Statistics Estonia

We considered using the sum of the quantity of hunted big game multiplied by the average quantity of meat obtained from the game species (weight of game carcass) and purchase price of game meat (without value-added tax (VAT)) a good approximation for the value of the ecosystem service of providing game.

$$Service\ value\ of\ providing\ game = \sum_{i=1}^{n} a_i * b_i * c_i + \sum_{i=1}^{n} a_i * d_i$$

where a_i - quantity of hunted game species;
b_i – average weight of the cold body of game species (kg);
c_i - average price of the meat of game species (without VAT) (€/kg);
d_i – price of skin of game species (without VAT) (€/kg);

The statistics for hunted game is available for the hunting year 2018/2019 (from March 2018 to February 2019), we considered it as an input for the year 2018. The statistics include hunted game for each hunting district, the area of hunting district and the number of users (hunters) of hunting districts.

Purchase prices of big game for the current year are available on web sites of meat processing companies. Additionally, meat processing companies were contacted to get the average weight of the cold body of the game.

The value of skins was also added. The purchase prices of skins of elk and red deer were obtained from the webpage of Estonian Hunters' Society[40] which purchases the skins for further reprocessing.

[39] Tiit Randveer. Jahiraamat. 2003

[40] http://www.ejs.ee/

3.3.3.3 Results

Table 18. Components of the market price of provisioning of game, 2018.

Game	Hunted game 2018/19	Average weight of cold body (kg)	Average purchase price of meat without VAT (€/kg)	VALUE of game meat (€)	Purchase price of skin (€ per skin)	VALUE of skins (€)	VALUE of the service (€)
Elk	7 163	205	3.5	5 139 453	11	78 793	
Red deer	2 757	95	2.1	550 022	4	11 028	
European roe deer	24 146	22.5	2.3	1 249 556			
Wild boar	4 761	109	2.65	1 375 215			
Brown bear	60	150	10	90 000			
TOTAL				**8 404 244**		**89 821**	**8 494 065**

Based on the calculations the ecosystem provisioning service value of providing game is 8.5 million €. The value of the components that make up the total value of providing game can be seen in Table 18. The biggest contributor to the value of the game meat are elk, followed by European roe deer and wild boar.

3.3.3.4 Spatial analysis

It is problematic to distinguish which ecosystem type provides the service as different game species roam in a wide area and often prefer mosaic landscape where different ecosystem types are present. Therefore, in the current assessment the service value for different ecosystem types was calculated using top-down approach.

First we calculated the value for the whole country by hunting districts. Then by merging the ecosystem unit map and hunting district map, we obtained the share (in area units) of each ecosystem type in the hunting district. Including all natural and vegetated ecosystems (excluding waterbodies, rocky slopes and artificial landscapes), we divided the service value per hunting district between ecosystem types according to the area of ecosystem type (service *value per hunting district*area of the ecosystem type/area of all ecosystem types present in the hunting district*).

From the obtained dataset of ecosystem service values for ecosystem types it was possible to derive the values of the ecosystem service of providing game for grasslands which are shown in Table 19. The contribution of the grassland ecosystems to the ecosystem service is 1.2 million €/year of which 557 thousand €/year is provided by semi-natural grasslands.

Table 19. The value of ecosystem service of providing game by grassland types, 2018, €

Grassland type	Value (€/year)
Boreal baltic coastal meadows	68 638
Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	1 141
Dry sand heaths with Calluna and Empetrum nigrum	140
Inland dunes with open Corynephorus and Agrostis	105
European dry heaths	1000
Juniperus communis formations on heaths or calcareous grasslands	13 546
Xeric sand calcareous grasslands	140
Calaminarian grasslands of the Violetaliacalaminariae	1
Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	14 676
Fennoscandian lowland species-rich dry to mesic grasslands	13 673
Nordic alvar and precambrian calcareous flatrocks	55 663
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	10 841
Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	7 480
Northern boreal alluvial meadows	43 469
Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	10 902
Fennoscandian wooded meadows	11 383
Fennoscandian wooded pastures	10 275
Other natural grassland	960
Environmental non-sensitive permanent grassland	592 745
Environmental sensitive permanent grassland	960
TOTAL	**1 150 711**

Visualization of the service provisioning areas and values of provisioning game of Estonian grasslands can be seen in Figure 5.

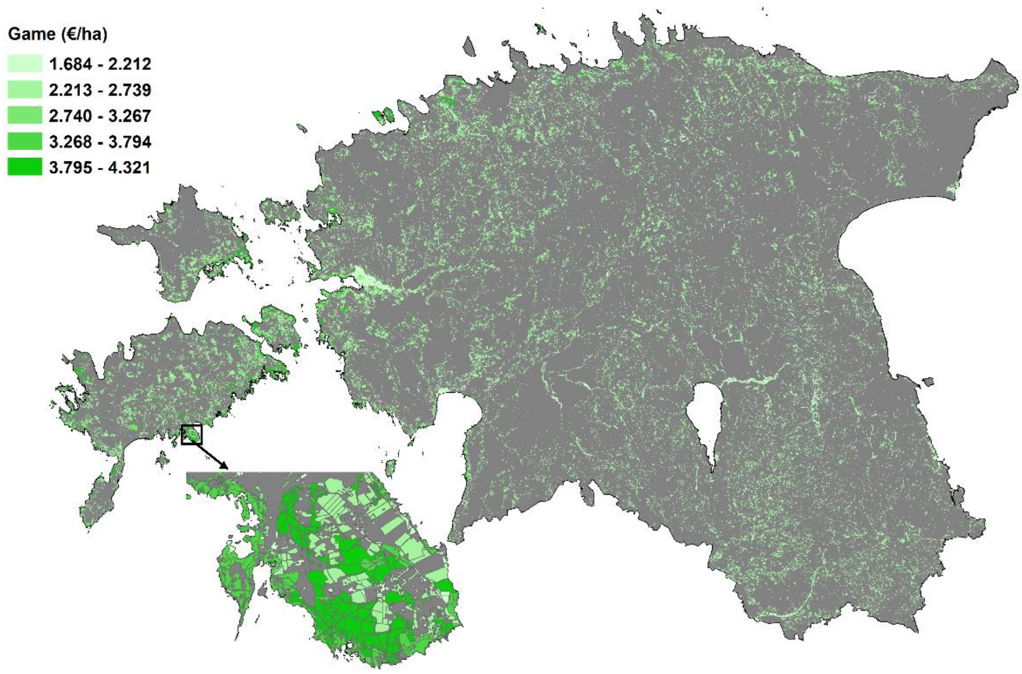

Figure 5. The ecosystem service provisioning areas and values of provisioning game of Estonian grasslands. The areas coloured in shades of green represent grasslands according to the value they supply the service that was calculated using market price approach. The values shown correspond to the total value of ecosystem service per grassland ecosystem type. Dark grey areas are other ecosystem types that were not analysed in the current work.

3.3.3.5 Conclusion

The ecosystem service value of providing game was calculated with market price approach. Using hunting statistics of hunted game by hunting districts and average purchase price of game meat (without VAT) the value was calculated and then distributed between ecosystem types. Based on the calculations the ecosystem service value of providing game by grassland ecosystems is 1.2 million €/year of which 557 thousand €/year is provided by semi-natural grasslands. When including all contributing ecosystems types in Estonia, the ecosystem service value was 8.5 million €/year.

The whole value per ecosystem can be considered as the contribution by the ecosystem to the ecosystem service of provisioning game as there is hardly any human input in the flow of the service which was assessed.

The problems that arose during assessment of the service were related to incomplete input data and determining which ecosystem types actually contribute to the provisioning of game. Both these problems will be looked into in the next phase of the project and now knowing the scarcity of data, we will work on improving the assessment methodology.

Adding the obtained values of the two ecosystem services: provisioning of game and recreational hunting was also suggested when double counting can be limited. The only shared part in the valuation of the service from the aspects of both approaches is the expenditure for hunting fees. For Estonian ecosystems the total value of the ecosystems services related to wild game is approximately 24.6 million €/year.

Providing game	8 493 551
Expenditure for hunting (without expenditure for hunting fees)	16 110 850
TOTAL (€/year)	24 604 401

However, in the current assessment we decided to keep the provisioning and cultural services related to hunting separate.

3.3.4 Provisioning of medicinal herbs

In Estonia, there is a long tradition of collecting different herbs from the wild and using these for medicinal purposes. Historically, over 120 plant species have been used as herbs in Estonia and the prognosis is that using herbs as tea mixtures and drugs will not be decreasing[41]. 'Drug' (Estonian '*droog*') refers to the natural substances used for medicinal purposes as it is defined in pharmacology.

Herbs are collected from the wild and used by households often as tea mixtures. Products produced from medicinal herbs (pure parts of the herb, tea mixes, extracts, pills etc.) are marketed in apothecaries, stores and markets. When used for marketing purposes, herbs are not only collected from the wild, but are also widely cultivated. For example herbs that are marketed in the largest quantities (flax seeds, chamomile, and caraway) are cultivated in herb fields, but there are also herbs (e.g. *Epilobium parviflorum*) which are collected from the wild. The market share of the latter may be smaller but it is an indicator that provisioning of medicinal herbs is an important ecosystem service.

3.3.4.1 Definition of the ecosystem service

The ecosystem service is providing medicinal herbs. It is defined as the provisioning of medicinal herbs by ecosystem asset (grassland) to the production of herbal goods. The economic benefits are the goods that are produced from medicinal herbs such as herbal tea mixtures, drugs and other herbal pharmaceutical products. The beneficiaries are households that consume products that are produced. The users of the ecosystem service of provisioning herbs are mostly farmers that grow and collect herbs and manufacture products from these.

3.3.4.2 Methods and data

Name of the dataset	**Data type**	**Source**
Herbs that were marketed over 100 kg in 2015	Table	Sepp. J., Raal, A. (2017) Ravimtaimede turustamisest Eestis aastal 2015
-	Market prices in 2019	raviminfo.ee
Ecosystem unit map	Spatial data	Statistics Estonia

Products made from medicinal herbs are market goods and therefore we considered using the sum of the amount of marketed medicinal herb that grow in the wild on grasslands multiplied by the average

[41] Pihlik, U. 1999. Ravimtaimed. Eesti bioloogilise mitmekesisuse ülevaate materjale. Tallinn-Tartu

price of the products made from the herb (without value-added tax (VAT)) a good approximation for the value of the ecosystem service that is providing medicinal herbs.

$$Service\ value\ of\ providing\ medical\ herbs = \sum_{i=1}^{n} a_i * b_i$$

where a_i - quantity of marketed medicinal herb that grow in the wild in the grasslands (kg);
b_i - average price of the products made from the herb (without VAT) (€/kg);

The assessment is based on the survey carried out on the quantities of herbs that were marketed in apothecaries. The data was collected directly from the companies situated in Estonia that own a permit to handle drugs according to the register of activity licences of Agency of Medicines of the Republic of Estonia. But using this data has its shortfalls: the survey was carried out in 2015 so the data is somewhat outdated. As the survey only investigated companies that market their products in apothecaries, other smaller companies that grow and collect herbs but sell them in stores or markets are excluded from the assessment. In future, developments of assess the service of providing medicinal herbs the idea is to use the data from wholesale companies and then also smaller producing companies are included in the assessment. Also the consumption of herbs by households is not examined in this assessment and the only way to count for them is to collect the data by carrying out a separate survey.

Data of marketed herbs from all the ecosystems was analysed in the survey. As a first step, it was necessary to determine the plant species that grow wildly on the grasslands to include them in the service assessment. This was achieved based on the habitat preference of the species. Additionally it was needed to determine if the herb that indeed grows on the grasslands was collected from the wild as some of the herbs listed in the survey are only collected from the wild, some are cultivated and collected from fields and for some both origins are possible. Herbs grown and collected from fields were excluded from the assessment. If the herb may be collected from the wild and also from the field, according to the expert opinion, a ratio 60:40 was applied, where 60% of the amount of the herb is most likely collected from the fields and 40% is collected from the wild.

The market price of an herb was taken as the average price of the products made from the herb (mostly pure parts of the herb and tea mixes) which was calculated based on the data taken from raviminfo.ee where all products that are marketed in apothecaries are listed. Prices without VAT were used in calculations to decrease the amount of human input in making the product. No further deductions of other human inputs were made.

3.3.4.3 Results

Table 20. Market price of medicinal herbs, 2018, €

Herb species	Habitat	Quantity of marketed herb (kg)	Price (€/kg w/o VAT)	Value of grassland plants collected from wild (€)
Rosa L.	Agricultural, Grasslands	525	65,36	13724,86
Carum carvi	Agricultural, Grasslands	509	31,65	6444,94
Arctostaphylos uva-ursi	Inland dune/ sandy plain	362	74,71	10817,74
Hypericum perforatum	Agricultural, Grasslands	315	85,30	10747,72
Epilobium parviflorum	Grasslands	284	44,76	12712,38
Achillea millefolium	Grasslands	476	77,14	36717,22
Thymus serpyllum	Agricultural, Grasslands	239	92,43	8836,08
Valeriana officinalis	Grasslands	202	50,14	10128,64
Origanum vulgare	Agricultural, Grasslands	186	95,72	7121,29
Taraxacum officinale	Grasslands, Urban	163	38,65	6300,06
Tussilago farfara	Agricultural, Grasslands	156	115,58	18030,57
Filipendula ulmaria	Grasslands	136	73,13	9946,13
Plantago major	Grasslands, Urban	132	89,28	11785,02
Crataegus	Grasslands	130	78,08	10150,73
Quercus robur	Grasslands, Forest	129	52,34	6752,02
Equisetum arvense	Grasslands	104	104,02	10818,57
			TOTAL	191034

Based on the calculations the ecosystem service value of providing medicinal herbs by grassland ecosystems were 191 034 €. The value of the components that make up the total value of providing game can be seen in Table 20.

3.3.4.4 Spatial analysis

The calculated monetary value of the ecosystem service of providing medicinal herbs was distributed among grassland types depending on the habitat requirements of the plant species. If several grassland types were suitable habitat for the species then the contribution of the ecosystem type was calculated by weighting the area of the grassland type to all contributing grasslands. The average unit value of providing medicinal herbs for grasslands was calculated to be 0.08 €/ha. The values of the ecosystem service of providing medicinal herbs by grassland ecosystem types is shown in Table 21.

Table 21. The value of ecosystem service of providing medicinal herbs by grassland types, 2018, €

Grassland type	Average value (€/ha)	Total value (€)
Boreal baltic coastal meadows	0.140	16716
Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	0.110	87
Inland dunes with open Corynephorus and Agrostis	0.167	18
Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	0.099	9010
Fennoscandian lowland species-rich dry to mesic grasslands	0.056	3085
Nordic alvar and precambrian calcareous flatrocks	0.085	11117
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	0.035	392
Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	0.035	386
Northern boreal alluvial meadows	0.035	2737
Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	0.198	3169
Fennoscandian wooded meadows	0.099	6002
Fennoscandian wooded pastures	0.138	2053
Environmental sensitive permanent grassland	0.029	144
Environmental non-sensitive permanent grassland	0.029	66348
Other natural grassland	0.040	69769
Grand Total	**0.080**	**191034**

Visualization of the service provisioning areas and values of provisioning medicinal herbs as ecosystem service of Estonian grasslands can be seen in Figure 6.

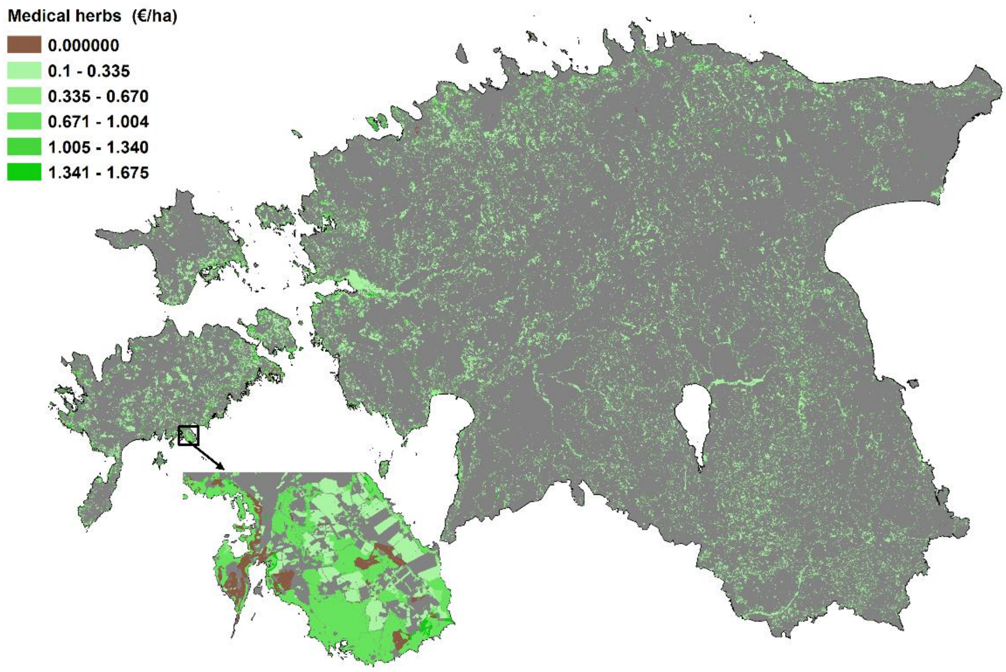

Figure 6. The ecosystem service provisioning areas and values of provisioning medicinal herbs of Estonian grasslands. The areas coloured in the scale from brown to green represent grasslands according to the value they supply the service that was calculated using market price approach. The values shown correspond to the total value of ecosystem service per grassland ecosystem type. Dark grey areas are other ecosystem types that were not analysed in the current work.

3.3.4.5 Conclusion

The ecosystem service value of providing medicinal herbs was calculated with market price approach. Using available data of the quantities and average price of the products made from the herbs (without VAT), the value was calculated and further distributed between grassland types based on the habitat requirements of the herb species. Based on the calculations the ecosystem service value of providing medicinal herbs by grassland ecosystems were 191 034 €.

The distribution of the monetary value of the ecosystem service of providing medicinal herbs between different grasslands proved to be a difficult task as most of the herbs are quite widespread and can inhabit several ecosystem types. Furthermore characteristics of some grassland types were not precise enough and no certain set of growing conditions could be determined there. Therefore the final distribution is quite general and should be specified in the future for more precise results.

The whole calculated result was taken as the contribution of the ecosystem and the contribution of the society to the value of the service was not separated. Corrections are needed to account for production costs (see chapter 4.2) but it is difficult to make with the current available data. There is room for improving the methodology in the next phase of the project. Also another approach to consider is applying replacement cost method in comparing producing medicinal herbs with producing artificial drugs which could be looked into in the future.

3.3.5 Climate regulation

The on-going process of carbon sequestration and the existing carbon storage contribute to climate regulation. Net carbon sequestration is the difference between net primary productivity and soil respiration. The storage of carbon in biomass and in soils is increased due to the process. Carbon cycle e.g. carbon storage in biomass and soils is relatively short-lived and changes in ecosystem processes influence the rate in which carbon is emitted or sequestrated.

3.3.5.1 Definition of the ecosystem service

According to CICES v5.1 regulating global climate is defined as regulation of the concentrations of gases in the atmosphere that impact on global climate or oceans (Table 22)[42]. In the current work two separate services are considered as climate regulation ecosystem service.

1. Net carbon sequestration;
2. Storage of carbon in the biomass and soils of grasslands.

The question whether beneficiaries are public sector or households has been discussed by the experts. In our SUT table households are considered as beneficiaries. Net carbon sequestration and storage in biomass and soil of grasslands have been assessed with different methods.

[42] Haines-Young, R. and M.B. Potschin (2018):Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Available from www.cices.eu

Table 22. Definition of the ecosystem service of climate regulation according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Regulation of chemical composition of atmosphere and oceans	2.2.6.1	*Regulating our global climate*	*Regulation of the concentrations of gases in the atmosphere*	*….that impact on global climate or oceans*	*Sequestration of carbon in tropical peatlands*	*Climate regulation resulting in avoided damage costs Or Mitigation of impacts of ocean acidification*

3.3.5.2 Methods and data

For the net carbon sequestration in grasslands, two methods were discussed: the social cost of carbon and payment for ecosystem service. The latter was considered relevant.

Name of the dataset	Data type	Source
-	Reference values (Emission Factors)	Greenhouse gas reporting of the LULUCF sector
European Union Allowance Price	Spot price	https://icapcarbonaction.com/en/ets-prices
Ecosystem unit map	Spatial data	Statistics Estonia

3.3.5.3 Valuation of carbon sequestration using PES schemes method

Based on available data, we considered payment for ecosystem services (PES) schemes the best technique to assess the monetary value of service. It is also a fairly straightforward method. European Union (EU) Emissions Trading System was chosen as an appropriate PES scheme and the yearly average European Union Allowance (EUA) price (€/t CO_2) was chosen as a unit price. The calculated yearly average EUA price was calculated to be 15.82 €/t CO_2.

National Inventory Report of greenhouse gas emissions in Estonia 1990-2017 of the LULUCF sector was the basis for the net carbon sequestration values for grasslands. The report contains a specific chapter on grasslands (6.4. GRASSLAND (CRF 4.C) p. 325), which provides an overview of carbon capture and emissions associated with grassland.

The main conclusion is that Grassland category has been mainly a small source of CO2; highest emissions originate from drained organic soils and from living biomass in the years of higher deforestation rates. Mineral soil pool has been a sink for CO2 due to land-use change to grasslands. The data presented in the report is important for the assessment of grassland carbon capture ecosystem service.

The Grassland category includes CO2 emissions and removals from living biomass, dead wood, mineral and organic soils, and non-CO2 emissions from biomass burning. The net emissions from Grassland were 37.8 kt CO2 eq. in 2017 (p 325). The report concludes that grassland category has mainly been a small source of CO2. Mineral soil pool has been a sink for CO2 only due to land-use change to grasslands (p 325).

An assumption was made to exclude input from change in carbon stocks in living biomass of trees due to not matching with the main concept of grassland. Considering trees grow in wooded meadows but these form a small share (%) from grasslands, they were not considered important. Under grasslands only the input of CO_2 emissions/removals from/by soils in LULUCF subcategory of "Grassland Remaining Grassland" was taken into account.

According to the assumptions, we have two findings from the National Inventory Report of greenhouse gas emissions in Estonia:[43]

1. Since grasslands are not actively managed (not cultivated) in Estonia, nor are additional inputs added to grassland soils, no changes are assumed in the Grassland Remaining Grassland mineral soil pool (Tier 1 approach as the ecosystem is assumed to be in steady state).

2. Organic grassland soils are considered drained and the loss of carbon for these is described by the emission factor -1.41 t C ha^{-1} yr^{-1}. The emission factors from Sweden are implemented in LULUCF assessment due to lack of country-specific data.

Based on these findings grasslands in Estonia as a whole do not offer carbon sequestration service.

It may be that in some locations and in some types of grassland carbon sequestration takes place but data for that kind of detailed analysis for grasslands is currently not available for Estonia.

3.3.5.4 Valuation of carbon storage in biomass and soil of grasslands. Willingness to pay for "climate control" ecosystem service. A contingent valuation study.

The underground part of the grassland ecosystem as a carbon stock has been kept in mind in defining the ecosystem service "climate control" in contingent valuation study carried out for the current report.

In National Inventory Report of greenhouse gas emissions in Estonia 1990-2017 of the LULUCF sector for land-use category „Grassland to Cropland" EF was -0.42 t C ha^{-1} yr^{-1} for mineral soil and -6.1 t C ha^{-1} yr^{-1} for organic soil.[44] This data indicates that the conversion of grassland to cropland is related to significant carbon emissions, which suggests that grassland soil is a valuable carbon sink and there is deposited a significant carbon stock.

A contingent valuation (CV) survey was conducted to find out willingness to pay (hereinafter WTP) for ecosystem services of Estonian grasslands. More detailed information on the theoretical background, methodology, sample and detailed results of CV study can be found in chapter 3.4. In the CV questionnaire, the grassland ecosystem service "climate control" was linked to carbon storage by grasslands.

According to respondents, the ecosystem service "climate control" was the second most important among all services in the questionnaire. (According to the respondents' opinion, the most important was "Habitat conservation for biological species").

[43] National Inventory Report. Greenhouse Gas Emissions in Estonia 1990-2017
[44] Ibid (p 321 table 6.2.1)

According to the methodology used by the authors, 2.0 million € can be attributed to the "climate control" as ecosystem service. This can be interpreted as the annual demand for meadow "climate control" ecosystem service. Based on the respondents' preferences of selected grassland types, out of the total WTP for the "climate control" service, 443 thousand € is attributable to cultural grasslands and 1.58 million € to semi-natural grasslands. The share of WTP attributable to semi-natural grasslands is further subdivided into 0.6 million € to woodland meadows, 0.5 million € to coastal meadows and 0.4 million € to flooded meadows.

According to spatial analyses, the area of cultivated grasslands in Estonia is 257 000 hectares and the area of semi-natural grasslands is 242 000 hectares. By dividing total annual WTP, 433 000 € for cultivated grasslands and 1580000 € for semi-natural grasslands by grassland areas (443000 €/257000 ha = 1.7 €/ha /y and 1580000 €/242000ha = 6.53 €/ha /y), we find the annual WTP for 1 hectare for both types of grasslands.

So, the annual WTP is 1.7 € for one hectare of cultivated grassland and 6.53 € for one hectare of semi-natural grassland.

Considering that the carbon storage ecosystem service is dependent on the soil type of grassland and not whether it is semi-natural or cultivated, the value of one tonne of carbon storage service should be attributed not according to the type of grassland but on the type of soil, dividing the entire WTP by hectares.

It is estimated that 419500 hectares of grasslands in Estonia are situated on mineral soils and 78950 hectares on organic soils. According to the methodology used, one hectare of organic soil stores 6.1 tonnes and mineral soil 0.42 tonnes of carbon.

Thus, grasslands on mineral soils store up to 176000 tonnes of carbon and grasslands on organic soils store 482000 tonnes of carbon. In total, Estonian grasslands store 658000 tonnes of carbon.

By dividing WTP for carbon storage by the total amount of carbon stored, we get 2000000 €/658000 tonnes = 3.03 €/tonne.

The annual WTP for storing 1 tonne of carbon by grassland is 3.03 €.

This value is much lower than the value calculated on the basis of the EUA unit price, which will be handled in next chapter.

For further methodological discussion, carbon storage value is a stable stock value, which is not directly comparable with annual carbon sequestration values.

3.3.5.5 Carbon storage value of grasslands based on the unit price of the EUA

For the valuation of carbon storage in soils of grasslands the assumption is that a certain amount of carbon from the carbon stock is in the soil due to the land being grassland. Therefore EF can be used as indicators: For land-use category „Grassland to Cropland“ the EF was EF was -0.42 t C ha^{-1} yr^{-1} for mineral soil and -6.1 t C ha^{-1} yr^{-1} for organic soil

To find the monetary value of carbon storage as ecosystem service through a European Union Allowance (EUA) unit price (average 15.82 €/t CO_2), one must first find the carbon content per tonne of carbon dioxide. Carbon has a relative atomic mass of 12. Oxygen has a relative atomic mass of 16, so two of them is 32. Therefore the share of carbon in carbon dioxide is 27.3 %. One tonne of carbon dioxide (CO_2) contains 273 kg of carbon (C).

In view of the above, storage of 273 kg of carbon in soil is worth 15.82 € and storage of one kg of carbon is 0.058 €.

According to spatial analyses, the total area of grasslands is 419 500 ha on mineral soils and 78950 ha on organic soils. Based on these area data and the unit price of the EUA, the approximate value of the organic soil grassland ecosystem service as a carbon storage is 28 million € (78950 ha x 6100 kg x 0.058 €) and the value of mineral soil grassland 10 million € (419500 ha x 420 kg x 0.058 €).

The total value of the Estonian grassland ecosystem service as a carbon storage is approximately 38 million €.

The average value of carbon storage per hectare is 76 €.

3.3.5.6 Spatial analysis

The monetary values of grassland carbon storage by different type of grasslands are given in Table 23. These values were obtained by first overlaying the map of grassland types with the map layer of soil types in Estonia. The carbon storage value of grassland type depends on whether it is on organic or mineral soil. The greatest value of carbon storage, over € 17 million, was found in cultivated grasslands which are on organic soils.

For semi-natural grasslands, the most valuable is unclassified "*grassland*" class on organic soils (6 million €). For the semi-natural grasslands which are situated on Natura sites, the highest carbon storage value, 3.5 million €, was for northern boreal alluvial meadow (6450).

Considering the large difference in carbon storage between organic and mineral soils, the carbon storage value of a particular type of grassland depends primarily on how much it is on the organic soils.

Grassland carbon storage value by type of grassland is shown in Table 23. Visualization of the service provisioning areas and values of carbon storage service of Estonian grasslands can be seen in Figure 7.

Table 23. Grassland carbon storage service values by type of grassland, 2018, €

Grassland type	**Mineral soil (ha)**	**Carbon storage value (€)**	**Organic soil (ha)**	**Carbon storage value (€)**
Boreal baltic coastal meadows	19 869	484 009	21	7 430
Fixed coastal dunes with herbaceous vegetation ("grey dunes")	397	9 671		
Dry sand heaths with Calluna and Empetrum nigrum	43	1 047	1	354
Inland dunes with open Corynephorus and Agrostis	27	658		
European dry heaths	523	12 740	38	13 444
Juniperus communis formations on heaths or calcareous grasslands	3 827	93 226	10	3 538
Xeric sand calcareous grasslands	32	780		
Calaminarian grasslands of the Violetaliacalaminariae				
Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	5 358	130 521	25	8 845
Fennoscandian lowland species-rich dry to mesic grasslands	5 868	142 944	299	105 786
Nordic alvar and precambrian calcareous flatrocks	14 589	355 388	24	8 491
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	2 843	69 255	850	300 730
Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	2 393	58 293	1260	445 788
Northern boreal alluvial meadows	15 754	383 767	10072	3 563 474
Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	5 008	121 995	337	119 231
Fennoscandian wooded meadows	4 456	108 548	109	38 564
Fennoscandian wooded pastures	2 947	71 789	11	3 892
Environmentally sensitive grassland	122	2 972	432	152 841
Cultivated grassland	207 815	5 062 373	48 207	17 055 637
Grassland	127 649	3 109 530	17257	6 105 527
TOTAL	**419 520**	**10 219 506**	**78 953**	**27 933 572**

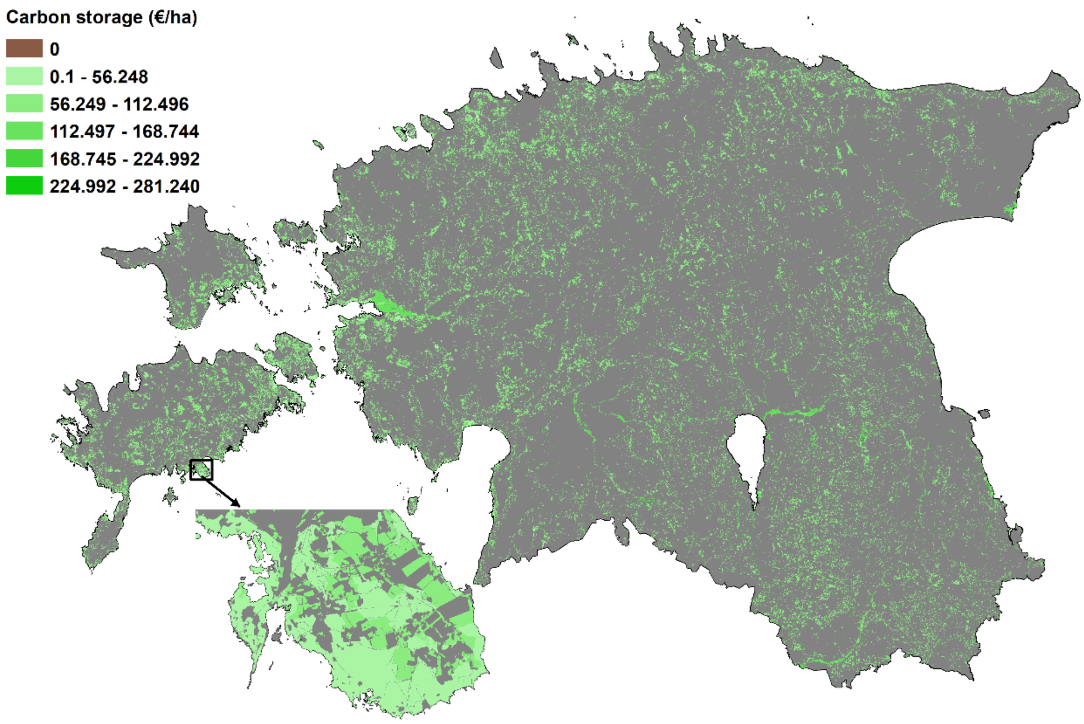

Figure 7. The ecosystem service provisioning areas and values of carbon storage service of Estonian grasslands. The areas coloured in the scale from brown to green represent grasslands according to the value they supply the service that was calculated using PES scheme method (EUA price). The values shown correspond to the total value of ecosystem service per grassland type. Dark grey areas are other ecosystem types that were not analysed in the current work.

3.3.5.7 Conclusions

The results of the applied approaches and concepts (C sequestration and C storage service) were discussed bilaterally and in a seminar. It was suggested by experts to follow a late 2019 UN SEEA EEA revision expert group outcomes as these questions i.e. the handling of the C sequestration and C storage service are still discussed on international level and definite solutions are currently not yet there. The same applies for the question how to treat negative values. i.e. disservices. It was acknowledged that carbon storage values based on CVM is a welfare value and this should not be added up with exchange values. Different methods were suggested for estimating carbon sequestration price in monetary terms, like social cost of carbon and different carbon prices. Using the price of tradeable CO_2 quotas in order to transfer these to carbon sequestration in biomass context was discussed and it was acknowledged that it reflects a real existing market, even though the values tend to be rather low because the market isn't functioning well. The use of non-market price with the expectation that the market price and non-market price would converge over time as carbon marketing develops was seen as a possibility. Social cost of carbon was considered not to be well aligned with SEEA and also difficult to validate.

The carbon storage service provision (based on quota prices) was decided to be included in assessment of ecosystem services. The conceptual questions would be a subject for future discussions and it would be useful to have the description in methodological report and to continue the analysis.

How to combine the results derived with the WTP survey regarding grasslands services with calculations based on real transactions was discussed as well and it was concluded that Statistics Estonia could elaborate both approaches and then explain the methods and analyse them as users are interested also in the total economic value not just the exchange value. So having them both available where appropriate and making clear which is which would meet the demand. Calculations could be presented in table in different columns indicating which is a welfare value and which an exchange value.

3.3.6 Pollination

Two different methods were used to value insect pollination (entomophily) as ecosystem service. First method was avoided cost method proposed by scientists of Wageningen University and Research [45] which requires spatial modelling and as a second method benefit transfer method was used.

Insect pollination is the transfer of pollen within and between flowers by insects. Pollination is a key ecological function facilitating reproduction in 78% of temperate flowering plants.[46] These plants underpin the function of a range of ecosystem services, such as food crop production, soil quality, pest regulation and improving landscape aesthetics.[47] About 90% of the world's flowering plants and about 75% of the world's leading crops depend on insect pollination. These crops represent a total of 35% of world production and, without pollination, crop production would be up to 90% lower. [48,49,50,51] 84 out of 264 horticultural crops in Europe need insect pollination.[3] Pollination increases the production of seeds of self-pollinating crops (e.g. oilseed) through more uniform ripening of the crop [5] and is often the only way for plants to reproduce and to diversify their genetic information.

Pollination benefit varies widely across studies but remains in the tens of billions of dollars a year.[52] The economic value of pollination is estimated to be between 37 and 91 billion dollars worldwide and between 5 and 14.6 billion dollars in the European Union.[53,54]

3.3.6.1 Definition of the ecosystem service

Pollination is classified as the regulating intermediate ecosystem service and crop pollination is defined here as the increased crop production in insect pollinator-dependent crops. The pollination ecosystem service is supplied by the ecosystems, more precisely, by pollinators who live at the local landscape, to

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[45] Remme, R., Lof, M., de Jongh, L., Hein L., Schenau, S., de Jong, R., Bogaart, P. (2018) The SEEA EEA biophysical ecosystem service supply-use account for the Netherlands. Wageningen University and Research

[46] Ollerton, J., Winfree, R., Tarrant, S. (2011) How many flowering plants are pollinated by animals? Oikos 120, 321-326.

[47] Lindemann-Matthies, P., Junge, X., Matthies D. (2010) The influence of plant diversity on people's perception and aesthetic appreciation of grassland vegetation. Biological Conservation 143, 195-202

[48] Breeze, T. D., Vaissiere, B. E., Bommarco, R., Petanidou, T., Seraphides, N., Kozak, L., Potts, S. G. (2014). Agricultural policies exacerbate honeybee pollination service supply-demand mismatches across Europe. PloS One, 9(1), e82996.

[49] Blacquiere, T., Smagghe, G., van Gestel, C. A., Mommaerts, V. (2012). Neonicotinoids in bees: A review on concentrations, side-effects and risk assessment. Ecotoxicology (London, England), 21(4), 973-992.

[50] Williamson, S. M., Willis, S. J., Wright, G. A. (2014). Exposure to neonicotinoids influences the motor function of adult worker honeybees. Ecotoxicology (London, England), 23(8), 1409-1418

[51] Rişcu (Jivan), A., Bura, M. (2013). The impact of pesticides on honey bees and hence on humans. Animal Science and Biotechnologies, 46(2), 272

[52] Millennium Ecosystem Assessment. Ecosystems and human well-being. Biodiversity Synthesis. Available: https://www.millenniumassessment.org/en/Reports.html (14.01.2019)

[53] Leonhadt, S.D., Gallai, N., Garibaldi,L.G., Khulmann, M., Klein A.M. (2013) Economic gain, stability of pollination and bee diversity decrease from southern to northen Europe. Basic and Applied Ecology 14, 461 – 471.

[54] Mänd, M. (2015) Mesilased kultuurtaimede tolmeldajatena. Ettekanne 11.07.2015 Olustvere

the economic user of the land (i.e. the farmer)[55]. Within the framework of this project economic benefit (as producer price) and rise of welfare (as consumer price) are gained due to pollination which therefore can be seen as a monetary value of pollination.

Economic benefits of pollination are crop production, maintaining supply of local products and aesthetics. The beneficiaries are enterprises and households.

3.3.6.2 Benefit transfer

3.3.6.2.1 Methods and data

The benefit transfer method is not a valuation method as such, but it is a method where benefits calculated for one place and time are transferred to another place and time or to the same place but another time.[56] In general, this is an acceptable method in environmental economics, under certain conditions (e.g resource constraints).

Main steps of benefit transfer are:

1. Identification of environmental goods and services to be valued.
2. Identification of the affected population and their socio-economic characteristics.
3. Literature search to identify relevant studies.
4. Estimated value transfer to the study site.
5. Calculation of total costs.
6. Assessment of the uncertainty and transfer error.

The benefit transfer method can be applied to all ecosystem goods and services. However, it is more reliable for transferring use values (e.g. recreation). We are aware that pollination is often regarded as an intermediate service and results obtained from this calculation are not usable in the national accounts.

For benefit transfer we chose three studies:

Leonhadt, S.D., Gallai, N., Garibaldi,L.G., Khulmann, M., Klein A.M. (2013) Economic gain, stability of pollination and bee diversity decrease from sothern to northen Europe. Basic and Applied Ecology 14, 461 – 471.

Breeze, T.D., Bailey, A.P., Potts, S.G., Balcombe, K.G. (2015) A stated preference valuation of the non-market benefiits of pollination services in the UK. Ecological Economics 111, 76-85

Mwebazea, P., Marrisa, G.,C., Brown, M., MacLeoda, A., Jonesa, G., Budgea, G.,E. (2018) Measuring public perception and preferences for ecosystem services: A case study of bee pollination in the UK. Land Use Policy 71 (2018) 355–362

[55] Hein, L. et al (2019) The economic value of ecosystem services and assets in the Netherlands. Wageningen University and Research.
[56] Oxford Research Encyclopedia. Available: https://oxfordre.com/environmentalscience/environmentalscience/view/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-455 (20.11.2019)

Leonhardt, et al. (2013) calculated the economic value of pollination based on the contribution of pollinators to agricultural production. The total economic value of insect pollination (EVIP) of crops was calculated according to the following equation:

$$\mathrm{EVIP} = \sum_{i=1}^{I}\sum_{c=1}^{C}\sum_{t=1}^{T}(P_{ict} \times Q_{ict} \times D_i)$$

where

P_{ict} is the unitary producer price of crop i for country c for year t;

Q_{ict} is the overall quantity of crop i for country c for year t;

D_i is the dependence ratio of crop i on insect pollinators.

As producer prices for the period 1991 – 2009 were available in the Food and Agriculture Organization of the United Nations (FAO) databases, this period was selected. Numbers of managed honeybee colonies were obtained from FAO as averaged for 1991 – 2009. Data for the numbers of wild bee species were retrieved from the *„Checklist of Western Palaearctic Bees"*. Data on the mean annual temperatures and rainfalls were obtained from *Worldclim - Global Climate*[57]. In the case of Estonia, three the most pollinator-dependent crops were chosen: cabbages, rapeseed, cucumber, and gherkins.

As a result of the study, the average annual economic value of insect pollination in Estonia was 10 million € per year, which makes up to 8% of the total annual value of plant production. The average annual economic value of insect pollination corrected for the agricultural area was 1 261 € per square kilometre. To convert the result into 2018 prices the purchasing power standard was used.

Breeze, et al (2015) and Mwebazea, et al (2018) studied willingness to pay of British society with an aim to assess the monetary value of pollinators. Breeze, et al (2015) used a choice experiment method with two scenarios: (1) maintaining the supply of local products; and (2) aesthetic benefits of various wildflowers. In general, willingness to pay was rated high in both scenarios. The results were respectively 24.6 and 13.4 pounds per annum per taxpayer. Mwebazea, et al (2018) used a contingent valuation method to study how much public supports policy that maintains bee colonies at the survey year level. Willingness to pay to support policy that protects bees was 71.2 pounds per annum per taxpayer.

To transfer the results of the British studies to the Estonian conditions we used average gross monthly/weekly wages in Estonia and the United Kingdom at survey year and the year 2018.[58,59] The exchange rates used for the conversion were taken from the European Central Bank.[60] The number of people employed, i.e. the number of taxpayers has been taken from Statistics Estonia's website.[61]

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[57] Fick, S.E. and R.J. Hijmans, 2017. Worldclim 2: New 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology

[58] https://www.stat.ee/stat-keskmine-brutokuupalk 25.05.2019

[59] https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/bulletins/familiesandhouseholds/2016 25.06.2019

[60] Available: http://ec.europa.eu/budget/graphs/inforeuro.html 25.06.2019

[61]Available: https://www.stat.ee/sab-uuendus?db_update_id=20758 25.06.2019

3.3.6.2.2 Results

Benefit transfer based on the results of Leonhardt, et al (2013) study gave us monetary value of pollination at producer prices and is 13.8 million € per year in 2018 prices. Benefit transfer based on results of Breeze, et al (2015) and Mwebazea, et al (2018) studies gave us monetary value of pollination at consumer prices and is 24.7 million € per year in 2018 prices. These values represent the total willingness to pay of society for pollination service.

Assuming that the total willingness to pay for pollination service in Estonia is known, the value of each ecosystem that provides pollination service was calculated. Table 25 shows the monetary value of the pollination service by grassland type.

3.3.6.2.3 Spatial analysis

The list of ecosystems includes 140 ecosystem units, including those that are not suitable for pollinator habitats (water bodies, fields, roads, etc.). The list includes grasslands that have been considered separately as semi-natural grasslands whereas these were treated by Natura 2000 habitat codes, and cultivated grasslands were identified as permanent grasslands whereas separately were treated environmental sensitive and non-sensitive permanent grassland.

To calculate the monetary value of pollination service provided by different ecosystems we collected data about the suitability of the ecosystem units for the habitat for wild pollinators such as wild bees, bumblebees, butterflies, and hoverflies. Wild pollinators require sufficient resources for nesting (e.g. suitable soil substrate, tree cavities, etc.) and sufficient forage (i.e. pollen and nectar). Ecosystems are different in suitability for habitat to pollinators. Based on SEEA EEA report[62], and expert knowledge of entomologist of University of Life sciences, professor Mänd and ecologist of Tallinn University, associated professor Rivis, we rated each ecosystem suitability for pollinators habitat on scale 0 – 100 where 100 means most suitable and 0 unsuitable.

Table 24. Suitability of Estonian ecosystem types for pollinator habitats, habitats where habitat suitability is 0 are excluded. Habitat suitability is valued on a scale of 0-100.

Ecosystem units	Ecosystem name	Habitat suitability
1220	Perennial vegetation of stony banks	5
1640	Boreal Baltic sandy beaches with perennial vegetation	5
2120	Shifting dunes along the shoreline with Ammophila arenaria ('white dunes')	5
2130	Fixed coastal dunes with herbaceous vegetation ('grey dunes')	20
2140	Decalcified fixed dunes with Empetrum nigrum	20
2180	Wooded dunes of the Atlantic, Continental and Boreal region	20
2320	Dry sand heaths with Calluna and Empetrum nigrum	30
2330	Inland dunes with open Corynephorus and Agrostis grasslands	40
4030	European dry heaths	30

[62] Remme, R. et al (2018) The SEEA EEA biophysical ecosystem service supply-use account for the Netherlands. Wageningen University and Research

Ecosystem units	Ecosystem name	Habitat suitability
5130	Juniperus communis formations on heaths or calcareous grasslands	30
6120	Xeric sand calcareous grasslands	50
6130	Calaminarian grasslands of the Violetalia calaminariae	50
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	90
6270	Fennoscandian lowland species-rich dry to mesic grasslands	50
6280	Nordic alvar and precambrian calcareous flatrocks	70
6410	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	25
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	10
6450	Northern boreal alluvial meadows	5
6510	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	15
6530	Fennoscandian wooded meadows	60
7110	Active raised bogs	10
7120	Degraded raised bogs still capable of natural regeneration	10
8210	Calcareous rocky slopes with chasmophytic vegetation	100
8220	Siliceous rocky slopes with chasmophytic vegetation	100
8240	Limestone pavements	100
8310	Caves not open to the public	100
9010	Western Taiga	50
9020	Fennoscandian hemiboreal natural old broad-leaved deciduous forests (Quercus, Tilia, Acer, Fraxinus or Ulmus) rich in epiphytes	50
9050	Fennoscandian herb-rich forests with Picea abies	10
9060	Coniferous forests on, or connected to, glaciofluvial eskers	70
9070	Fennoscandian wooded pastures	100
9080	Fennoscandian deciduous swamp woods	10
9180	Tilio-Acerion forests of slopes, screes and ravines	90
91D0	Bog woodland	5
91E0	Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)	5
91F0	Riparian mixed forests of Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers (Ulmenion minoris)	5
Aianduslik maa	Kitchen gardens	30
AN	Filipendula site type	10
Eraõu	Private garden	50
Haljasala	Green area in settlements	30
Jäätmaa	Barren vegetation	30
JK	Oxalis site type	5
JM	Oxalis-Myrtillus site type	5
JO	Oxcalis drained swamp site type	5
JP	Oxalis-Rhodococcum site type	5
Kalmistu	Cemetery	20
Karjatamine väljaspool põllumaj. maad	Grazing outside of agricultural areas	40
Keskkonnatundlik püsirohumaa	Environmentally sensitive permanent grassland	50
KL	Galamagrostis-alvar site type	30
Klibune ala	Coastal shingle	10

Ecosystem units	Ecosystem name	Habitat suitability
KM	Polytrichum-Myrtillus site type	10
KN	Calluna site type	30
KP	Reclamationed pits site type	10
KR	Polytrichum site type	10
KS	Drained swamp site type	10
Liivane ala	Sandy shore	30
LL	Arctostaphylos-alvar site type	30
LP	Reclamationed pits site type	30
LU	Sesleria-alvar site type	30
Lühiajaline rohumaa	Short term grass field	10
Mahajäetud turbaväli	Abandoned peatlands	10
Mets	Forest	5
MO	Myrtillus drained swamp site type	10
MP	Reclamationed pits site type	10
MS	Myrtillus site type	10
ND	Aegopodium site type	20
OS	Equisetum site type	15
PH	Rhodococcum site type	10
Põõsastik	Shrubbery	5
Püsikultuurid	Permanent crops	40
Püsirohumaa	Permanent grassland	50
Raba	Oligotrophic bog site type	10
RB	Oligotrophic bog site type	10
Rohumaa	Grassland	50
SJ	Dryopteris site type	15
SL	Hepatica site type	50
SM	Cladonia site type	30
SN	Vaccinium uliginosum site type	30
SP	Reclamationed pits site type	5
SS	Transitional (mesotrophic) bog site type	10
TA	Carex-Filipendula site type	15
Tagasirajatud rohumaa	Restored grassland	50
TP	Reclamationed pits site type	5
TR	Carex site type	15

By using habitat suitability rates, habitat areas and the total willingness to pay for pollination obtained from benefit transfer we calculated the monetary value of pollination service (MVofP) for all the ecosystems that were included in the study list. For the calculation we used the following equation:

$$MVofP = \frac{WTP * \; HPi * Si}{100 * \; \sum_{i=0}^{n} PSi}$$

where

WTP is total willingness to pay (obtained from benefit transfer), €

S_i is area of the habitat, ha
HP_i is habitat suitability for pollinators
PSi is area for 100% pollination, ha.

By dividing the ecosystem monetary value of pollination service with the area, the value of the pollination service of one hectare was obtained.

Table 25. Monetary value of pollination service of different grassland types according to benefit transfer method, 2018, €

Ecosystem code	Grassland type	Habitat suitability for pollinators (scale 0 - 100); [HPi]	Habitat area, ha; [Si]	Average pollination value*, EUR/a	Average pollination value per hectare, EUR/ha/a
1.	**Grassland**		**497952,0**	**6905621,4**	**13,9**
1.1.	**Natural and semi-natural grassland**		**241953,7**	**3048120,8**	**12,6**
1.1.1.	**Semi-natural grassland according to the NATURA classification**		**97044,4**	**864560,7**	**8,9**
1.1.1.1.	Boreal baltic coastal meadows	0,0	19946,3	0,0	0,0
1.1.1.2.	Fixed coastal dunes with herbaceousvegetation (“grey dunes”)	20,0	396,8	2391,9	6,0
1.1.1.3.	Dry sand heaths with Calluna and Empetrum nigrum	30,0	43,2	390,8	9,0
1.1.1.4.	Inland dunes with open Corynephorus and Agrostis	40,0	27,3	329,7	12,1
1.1.1.5.	European dry heaths	30,0	561,4	5075,4	9,0
1.1.1.6.	Juniperus communis formations on heaths or calcareous grasslands	30,0	3837,2	34692,0	9,0
1.1.1.7.	Xeric sand calcareous grasslands	50,0	32,4	488,1	15,1
1.1.1.8.	Calaminarian grasslands of the Violetaliacalaminariae	50,0	0,4	6,0	15,1
1.1.1.9.	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	90,0	5380,7	145942,8	27,1
1.1.1.10.	Fennoscandian lowland species-rich dry to mesic grasslands	50,0	6175,3	93052,7	15,1
1.1.1.11.	Nordic alvar and precambrian calcareous flatrocks	70,0	14616,3	308343,2	21,1
1.1.1.12.	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	25,0	3692,6	27821,2	7,5
1.1.1.13.	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	10,0	3640,6	10971,6	3,0
1.1.1.14.	Northern boreal alluvial meadows	5,0	25811,4	38893,8	1,5
1.1.1.15.	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	15,0	5348,0	24175,8	4,5
1.1.1.16.	Fennoscandian wooded meadows	60,0	4569,2	82620,2	18,1
1.1.1.17.	Fennoscandian wooded pastures	100,0	2965,3	89365,6	30,1
1.1.2.	Other natural grassland	50,0	144909,3	2183560,1	15,1
1.2.	**Cultivated grassland**		**255998,3**	**3857500,6**	**15,1**
1.2.1.	Permanent grassland	50,0	255998,3	3857500,6	15,1
1.2.1.1.	Environmental non-sensitivive permanent grassland	50,0	255444,3	3849152,5	15,1
1.2.1.2.	Environmental sensitivive permanent grassland	50,0	554,0	8348,3	15,1

* Average pollination value = (pollination value in producer price + pollination value in consumer price)/2

Approximately 6.9 million € per year or 36% of the average willingness to pay of the pollination service is the value of the grassland pollination service. This amount is divided by a ratio of 1.26 between semi-natural and cultivated grasslands. The average value of pollination service is the highest, 30.1 €/ha/a, for Fennoscandian wooden pastures followed by semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia), 27.1 €/ha/a and nordic alvar and precambrian calcareous flatrocks, 21.1 €/ha/a. The average pollination value of cultivated grassland is a bit higher (15.1 €/ha/a) than semi-natural grasslands (12.6 €/ha/a).

Based on the results of benefit transfer, a map to illustrate pollination service supplied by different grassland was compiled (Figure 8*Figure 8*).

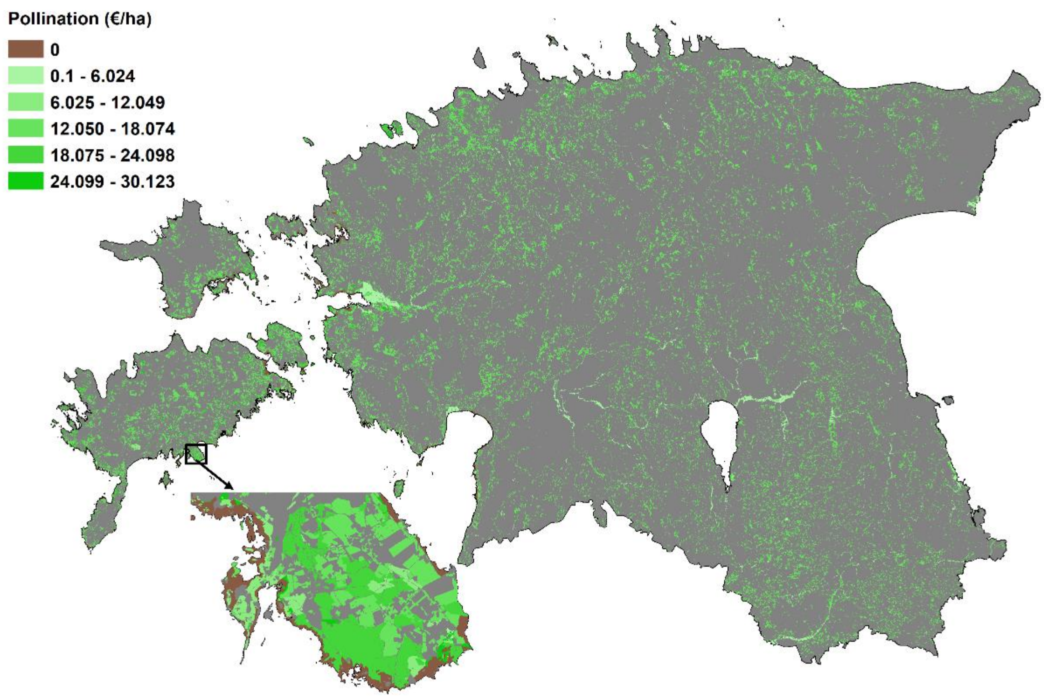

Figure 8. The ecosystem service provisioning areas and values of pollination service of Estonian grasslands. The areas coloured in the scale from brown to green represent grasslands according to the value they supply the service that was obtained by benefit transfer method. The values shown correspond to the total value of ecosystem service per grassland type. Dark grey areas are other ecosystem types that were not analysed in the current work.

3.3.6.3 Avoided damage cost method

As we were not sure of the timely finishing of the work and the quality of the results obtained by other method we alternatively used a benefit transfer method to find the monetary value of pollination service.

3.3.6.3.1 Methods and data

Avoided damage cost method is one of the cost-based valuation methods. In this method, the prices are estimated in terms of the value of production losses or damage that would occur if the ecosystem services were reduced or lost due to ecosystem changes.[63]

Based on the definition, according to which pollination ecosystem service is the increase in crop production due to the presence of the pollinators, the monetary value of the increase in crop production is taken to describe production losses in avoided damage cost method, which is the estimation of the ecosystem service value.

Name of the dataset	Data type	Source

[63] UN (2017) SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft. New York, USA. https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

AG0281: Agricultural land and crops by county, 2018	Statistics	Statistics Estonia
Basic unit prices of agricultural crop products, 2018	Statistics	Statistics Estonia
Habitat suitability for pollinators in Estonia	Table	Kennedy et al. (2013), modified for Estonia
Pollination requirements	Table	Klein et al. (2007), modified for Estonia
Agricultural support and land parcels, 2018	Spatial data	Estonian Agricultural Registers and Information Board (ARIB)
Ecosystem unit map	Spatial data	Statistics Estonia

To apply the avoided cost method, it was first necessary to model the biophysical service flow using spatial data of crops and pollinator habitats. The methodology proposed by scientists of Wageningen University and Research [64] was followed for calculating and modelling of the biophysical value of the pollination service. However, it was needed to make some modifications in the methodology as original calculations in the Netherlands were done using raster data with fixed cell size, but currently Estonian spatial input was in vector format.

First the calculations were done in a test area, namely Rapla county. Crop field units with their respective grown crop, pollinator habitat units and distances between them were derived through spatial analyses. On all crop field units where a crop which requires pollination is grown and all suitable habitat units within 1750 meter radius (from the middle of crop field unit to the middle of habitat unit) of the crop field unit were chosen to the dataset on which calculations were done. Due to time constrains the spatial data was not transformed from vector to raster, therefore further calculations were done in table form and therefore the precision of the modelling also decreased.

Pollination requirement was linked to the crop field units based on the crop grown there and habitat suitability per ecosystem type was linked to habitat units.

Crops differ in pollination demand. Based on the pollination requirement of the crop, crop field units were assigned a value of pollination requirement on the scale of 0-100. The values for the pollination requirement (Table 26) were derived from Klein et al. (2007) and modified for Estonia with the expert knowledge of entomologist of University of Life sciences, professor Mänd.

[64] Remme, R., Lof, M., de Jongh, L., Hein L., Schenau, S., de Jong, R., Bogaart, P. (2018) The SEEA EEA biophysical ecosystem service supply-use account for the Netherlands. Wageningen University and Research

Table 26. Crops and their pollination requirement (scale 0-100).

Crop name	Pollination demand, %
Oilseed rape, summer	25
Oilseed rape, winter	25
Rapeseed, summer	100
Rapeseed, winter	100
Beans	5
Peas	25
Buckwheat	90
Trifolium	75
Alfalfa	5
Linen seed	5
Fruits and berries	65
Vegetables, open field	25

The suitability of ecosystem types as pollinator habitats was assigned according to the sufficient resources for nesting (e.g. suitable soil substrate, tree cavities, etc.) and sufficient forage (i.e. pollen and nectar) for wild pollinators (wild bees, bumblebees, butterflies, and hoverflies). The methodology of assigning habitat suitability is further described in subsection 3.3.6.2.3 and habitat suitability rates are shown in Table 24.

Using the obtained dataset the relative visitation rate (scale 0-100) in crop field unit c from surrounding habitat units h was calculated [65]

$$v_c = \sum_{h=1}^{H} S_h \frac{e^{-0.00053 d_{hc}}}{\sum e^{-0.00053 d}}$$

where

S_h represents the relative pollinator abundance (scaled 0 – 100, where 100 marks maximum suitability) in map unit h (based on the suitability for nesting and foraging for pollinators of the habitat in map unit h), habitat suitability.

d_{hc} is the distance between map unit h and the crop in map unit c.

d describes the distance between the crop field unit c and any possible ecosystem around it.

$\Sigma e^{-0.00053d}$ describes the sum of all the distances between the crop field unit c and all possible ecosystems around it.

To use this equation for vector data (polygons) an estimation of the average d was needed, this was obtained based on the average area of crop field. The value of d in our test area was calculated on raster map with the help of Dr. Ir. Marjolein Lof from Wageningen University & Research. For the field with an area of 8.696 ha, which translates into a square cell measured 295x295 m it was calculated how many

[65] Remme, R., Lof, M., de Jongh, L., Hein L., Schenau, S., de Jong, R., Bogaart, P. (2018) The SEEA EEA biophysical ecosystem service supply-use account for the Netherlands. Wageningen University and Research

fields, and at what distances, an ecosystem providing pollination can potentially be connected with. If all natural vegetation within 6 km radius of the crop field is taken into account, the sum of all visitation rates ($\Sigma e^{-0.00053d}$) is 212. The obtained value of d was used in the calculations as a constant. If the crop fields in the local landscape are bigger or smaller than the average size of crop field based on which the d was calculated on, it will result in an under or over estimation of pollinator visitation rate and thereof also the ecosystem service value.

Pollination P_c is a function of the relative visitation rate,

$$P_c = f(v_c)$$

where $P_c = 5v_c$ for v_c between 0 and 20 and 100 for $v_c \geq 20$.

Next potential crop production reduction which is described by crop yield (€) = yield per hectare by county (kg/ha) * average crop basic price (€/kg)*crop field area (ha) in absence of pollination was calculated. Here in the calculations changing from yield (kg) to yield (€) gives the monetary value of the ecosystem service instead of biophysical.

The avoided production reduction represents the use of the pollination service by the crops. Avoided production reduction in the presence of pollinators APR_c is calculated

"Avoided production reduction" = "potential production reduction" * ("pollination")/100

The contribution (supply) of the ecosystems to the avoided production reduction, APRh is calculated:

$$APR_h = \sum_{c=1}^{C} APR_c \frac{\sum_{h=1}^{H} S_h \frac{e^{-0.00053 d_{ch}}}{\sum e^{-0.00053 d}}}{\sum_{h=1}^{H} S_h}$$

where

APR_c is the avoided production loss in the crop in map unit c,
d_{ch} is the distance between the crop c and the pollinator habitat h.
S_h is relative pollinator abundance in map unit h. Contribution to avoided production loss in crop fields by the ecosystem in map unit h is based on all crop fields that require pollination in a 6 km square around map unit h. This is calculated for all map units that contain an ecosystem that is suitable for pollinators.

3.3.6.3.2 Results

The value of pollination ecosystem service was obtained for Rapla county by following the modified calculations of the modelling of avoided production reduction in the presence of pollinators. The total value of pollinator service for Rapla county is 1.3 million €.

After successful testing of the afore described calculation, the methodology was planned to be extended on the whole country. However, we were not prepared to process such a big amount of data and therefore the modelling of the service for the whole country could not fit in the timeframe of the project.

Still, we used a more generalized way to extrapolate the pollination service value which we obtained for the Rapla County.

The value of the pollination service for the whole country is 21.2 million € which was calculated as: ecosystem service: service value in the test area/area of the crop fields in test area*area of crop fields in the country (1293222/7818*128216).

We followed the same approach as described in spatial distribution of benefit transfer method of pollination where by dividing the ecosystem monetary value of pollination service with the area of the ecosystem, the value of the pollination service for one hectare was obtained. The pollination service value attributed to grasslands is 7.6 million. The division of the pollination ecosystem service value between different grassland types is shown in Table 27.

Table 27. Pollination service value by grassland types according to avoided cost method, 2018, €

	Grassland type	**Habitat suitability for pollinators (scale 0 - 100); [HPi]**	**Habitat area, ha; [Si]**	**Area for 100% pollination, ha; [PSi]**	**Pollination value, €/a**	**Average pollination value per hectare, €/ha/a**
1.	**Grassland**		498 506	229 419	7 617 465	15
1.1.	Semi-natural grassland		241 954	101 142	3 358 267	14
1.1.1.	Semi-natural grassland according to the NATURA classification		97 044	28 688	952 530	10
1.1.1.1.	Boreal baltic coastal meadows	0	19 946	0	0	0
1.1.1.2.	Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	20	397	79	2 635	7
1.1.1.3.	Dry sand heaths with Calluna and Empetrum nigrum	30	43	13	431	10
1.1.1.4.	Inland dunes with open Corynephorus and Agrostis	40	27	11	363	13
1.1.1.5.	European dry heaths	30	561	168	5 592	10
1.1.1.6.	Juniperus communis formations on heaths or calcareous grasslands	30	3 837	1 151	38 222	10
1.1.1.7.	Xeric sand calcareous grasslands	50	32	16	538	17
1.1.1.8.	Calaminarian grasslands of the Violetaliacalaminariae	50	0	0	7	17
1.1.1.9.	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (*important orchid sites)	90	5 381	4 843	160 792	30
1.1.1.10.	Fennoscandian lowland species-rich dry to mesic grasslands	50	6 175	3 088	102 521	17
1.1.1.11.	Nordic alvar and precambrian calcareous flatrocks	70	14 616	10 231	339 717	23
1.1.1.12.	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	25	3 693	923	30 652	8
1.1.1.13.	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	10	3 641	364	12 088	3
1.1.1.14.	Northern boreal alluvial meadows	5	25 811	1 291	42 851	2
1.1.1.15.	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	15	5 348	802	26 636	5

	Grassland type	Habitat suitability for pollinators (scale 0 - 100); [HPi]	Habitat area, ha; [Si]	Area for 100% pollination, ha; [PSi]	Pollination value, €/a	Average pollination value per hectare, €/ha/a
1.1.1.16.	Fennoscandian wooded meadows	60	4 569	2 741	91 027	20
1.1.1.17.	Fennoscandian wooded pastures	100	2 965	2 965	98 459	33
1.1.2.	Other semi-natural grassland	50	144 909	72 455	2 405 737	17
1.2.	**Cultivated grassland**		256 552	128 276	4 259 199	17
1.2.1.	Permanent grassland		256 552	128 276	4 259 199	17
1.2.1.1.	Environmental non-sensitivive permanent grassland	50	255 998	127 999	4 250 001	17
1.2.1.2.	Environmental sensitivive permanent grassland	50	554	277	9 198	17

3.3.6.4 Discussion

We have found relatively reliable articles for revenue transfer. Breeze, et al (2015) and Mwebazea, et al (2018) used a stated preference approach to deliver results. In environmental economics, methods that follow this approach are valued as reliable methods that provide the best possible information on the willingness to pay of society. The method used by Leonhardt, et al (2013) belongs to a group of revealed preferences methods and is also rated reliable. Benefit transfers can only be as accurate as of the initial value estimate but the adequacy of existing studies is difficult to assess.

Interpreting the results obtained by using the benefits transfer method, one must consider that results are likely accurate only in case of use-value calculation (value of tradeable objects). As pollination service is regarded as intermediate service and it has non-use value then the accuracy of results of our calculations can be assessed as appropriate for strategic decision making.

Table 28. The comparison between monetary value of pollination service calculated in this report with benefit transfer method and presented in the report of Hein, L. et al (2018)[66]

Ecosystem unit	Report of Hein, L. et al (2018)[67]		This study	
	Average pollination value (as total avoided reduction of yield) in the presence of pollinators) (mln €)		Habitat area, hectare	Average pollination value, (mln €)
	2015	**2016**	**2018**	**2018**
Grassland*	119.1	117.6	497 952	6.9
Vegetated dunes	0.2	0.2		
Active coastal dunes	0.2	0.2		
Heath land	5.7	6.3		
Inland dunes	0.1	0.1		
Hedgerows/Shrubbery	12.9	13.0	14 929	0.02
Deciduous forest	45.5	46.2		
Coniferous forest	9.8	10.6		
Mixed forest**	20.1	21.4	1 993 683	7.9
Fresh water wetlands	4.6	4.7	10 222	0.03

* In study case grassland includes heath land, inland dunes, vegetated tunes and active coastal tunes.

** In study case all Estonian forests are designated mixed forests.

[66] Hein, L. et al (2018) The economic value of ecosystem services and assets in the Netherlands. Wageningen University and Research.
[67] Ibid

Table 28 shows significant differences between the results reported in Hein, et al (2018) report and those obtained in this study. The value of the pollination service obtained in this study is very low. The results should be viewed as relative values per ecosystem units as absolute units are not compareable.

Hein, L. et al (2018)[68] have noted in the appendix: "*If the resource rent method would be used, the contribution of the pollination service would, therefore, be very small or negative, while it is generally acknowledged that pollination is an important service for agriculture!*" This remark demonstrates need to be critical about the results obtained.

Whereas the avoided cost method was not applied as a fully spatial modelling method, the results were obtained by modifying the calculations and these coincide rather well with the results of benefit transfer method. Modelling the avoided cost method spatially is planned in the future. In the current study, we consider the result of the benefit transfer method to be more accurate. Still, the level of accuracy of the results allows to use them merely for strategic planning.

3.3.7 Nature recreation

The recreational service of ecosystem is expressed through direct human contact with nature. For many urban people, spending leisure time in the nature is often the only way to stay in direct contact with nature. Therefore, recreational ecosystem service is in many cases the only ecosystem service which gives people an immediate idea of ecosystems and is therefore of great importance.

As a rule, people do not pay for staying in nature for recreational purposes. This causes difficulties in estimating the monetary equivalent of the value of the service. In the economic context, the recreational service value is non-market by nature and therefore non-market valuation methods should be applied. The choice of a suitable method will depend largely on the availability of data related to the recreational service.

The most widely used method for the economic evaluation of ecosystem recreational service is the travel cost method (e.g. Champ et al. 2003[69]), which is based on the individual expenditures of the recreational service users. The limiting factor of using the travel cost method is that the consistent implementation of the method requires a large number of users of the recreational services to be interviewed.

Another possible approach to estimate the ecosystem service value of a recreational service is *time use* based approach. This approach is based on the assessment of the monetary value of the time involved in using the service and assessing the monetary value of time for ecosystem service. The use of the time-based method requires data on the number of users of the recreational service and the time spent on using it. Both these conditions were fulfilled for the current study and the time value based method was therefore applicable.

A third option for estimating the economic value of a recreational service is a contingent valuation method which is based on a stated preferences. As mentioned earlier, contingent valuation study was carried out parallel to our study and therefore the input from the CV was also available to us.

[68] Ibid
[69] Champ, P., Boyle, K., Brown, T (eds.). A Primer on Nonmarket Valuation. Kluwer Academic Publishers, 2003

3.3.7.1 Definition of the ecosystem service

Ecosystems provide attractive environments for leisure activities. The ecosystem recreational ecosystem service is defined as opportunities for/enabling nature related tourism/recreation. In this report, we discuss recreational ecosystem service from the point of view of the end users – households and non-residents – as beneficiaries. In this situation, the contribution of ecosystems to recreation and tourism are combined with human inputs (e.g. visitor centres, gazebos, walking paths etc.) to produce recreational benefits. In SNA terms, the economic benefits are increased consumer expenditure (which contributes to GDP), but also better health for the people who enjoy nature (which indirectly contributes to GDP). Furthermore, the ecosystem also contributes to the well-being of those who enjoy nature, but these welfare values are not part of SNA exchange values.

3.3.7.2 Cost based approach

3.3.7.2.1 Method and data

Name of the dataset	Data type	Source
Expenditure on the construction and maintenance of infrastructure	Statistics	State Forest Management Centre
Expenditure on the construction and maintenance of infrastructure	Statistics	Estonian Health Trails Foundation
Ecosystem unit map	Spatial data	Statistics Estonia

According to the literature of environmental economics, there are different methods to calculate monetary value of ecosystem goods and services. The most appropriate methods for valuing non-market goods and services in a view of environmental economics are travel costs method, contingent valuation method and choice experiment method. [70,71,72] In the frame of this project, we did not use the above listed methods and we looked for other options that can operate with already existing data.

The cost-based methods belong to the group of revealed preference methods and estimate values of ecosystem goods and services based on either the costs of avoiding damages due to lost services, the cost of replacing environmental assets, or the cost of providing substitute goods or services. At this point it is assumed that the costs incurred are equal to the willingness to pay of the society for ecosystem goods and services. These costs are used as a proxy for the monetary value of ecosystem goods and services. In environmental economics cost based methods are rarely used for evaluation of recreational services.

However, for the calculation of the monetary value of recreational services we decided to use the approach that is based on the principles of cost based methods. We assume that costs incurred for establishment and maintenance of recreational infrastructure express society's willingness to pay for nature recreational services and are seen as proxy for the monetary value of recreational service.

[70] Garrod G., Willis K.G. (2001) „Ecosystem Valuation of the Environment". Edward Elgar, USA
[71] Hanley N., Barbier E.B. (2009) Pricing Nature. Cost-benefit Analysis and Environmental Policy. Edward Elgar. Chetenham
[72] Thomas J.M., Callan S.J. (2007) Environmental Economics. Applications, Policy, and Theory. Thomson. South-Western. Australia

The majority of Estonian natural recreational sites are managed by State Forest Management Centre (654 places) and Estonian Health Trails Foundation (116 places). In 2018, expenditures of State Forest Management Centre for the establishment and maintenance of one nature recreation place was on average ca 9300 €. We assumed that regardless of who owns a natural recreational site the average annual maintenance cost is similar. Altogether expenditures for establishment and maintenance of natural recreation sites were 7.2 million € in 2018. Approximately 15% of this amount was spent for infrastructure that were located on the grasslands.

3.3.7.2.2 Monetary valuation of ecosystem recreational service based on costs for establishing recreational infrastructure

Table 29. Monetary value of recreational ecosystem service, 2018, €

Manager of the recreational places	Number of recreational places	Expenditures for establishment and maintenance of places in 2018 (million €)
State Forest Management Centre	654	6.1*
Estonian Health Trails Foundation	116	1.1
Total	770	7.2

* Nature education costs are excluded

Based on the expenditures of State Forest Management Centre and Estonian Health Trails Foundation for establishment and maintenance of nature recreational places and considering our above mentioned assumption (costs incurred for establishment and maintenance of recreational infrastructure express society's willingness to pay for nature recreational services and are seen as proxy for the monetary value of recreational service) we conclude that the monetary value of ecosystem recreational service is 7.2 million € in 2018. This result reflects the monetary value of recreational services of all ecosystems.

3.3.7.3 Time use based approach

3.3.7.3.1 Method

Estimations of monetary value of time are most often encountered in cost-benefit analysis of transport projects where time saving is an important factor (Meunier, Quinet, 2014)[73]. Various studies have quantified travel time unit costs and the value of travel time savings, based on analysis of business costs, traveller surveys, and by measuring behavioural responses by travellers faced with a trade-off between time and money. For example, when offered the option of paying extra for a faster trip (Transportation cost…)[74]. However, the use of the monetary value of time is not limited to transport projects, but is also applicable to the evaluation of other time consuming activities and associated values.

When evaluating a recreational ecosystem service, using time value, the monetary value of the leisure (non-working) time must be first determined. While the value of working time is generally related to the individual's income, different approaches are used to determine the value of leisure time. There are two approaches for monetary valuation of leisure time, which are either subjective valuation of people to the value of their leisure time or a fixed percentage of the value of working time which is associated with income.

[73] David Meunier, Emile Quinet. Value of Time estimations in Cost Benefit Analysis: the French experience.. Transportation Research Procedia 8 (2015) 62-71.
[74] Transportation Cost and Benefit Analysis II – Travel Time Costs. Victoria Transport Policy Institute (www.vtpi.org).

In Finland, empirical comparisons have shown that about 35 percent of gross wages and salaries, including social costs, reflect average time value (Tiehallinto 2005, p. 28)[75]. For example, a French study (Meunier, Quinet, 2014) estimates the value of one hour on personal-holiday trips, which best meets the definition of leisure, to be 6.8 €. In Finland, the value of time spent on holiday trips is 7.22 € per hour, which is very close to that found in the French study.

The European Union has conducted a study within the Heatco project analyzing the practice of cost-benefit analysis in 25 EU countries (Heatco 2006)[76]. The corresponding value for Estonia is 4.99 €. Heatco does not recommend using wages as an indicator of time value but recommends that the valuation should be based on a time-value based on a WTP study (ibid. p. 54). However, it is acknowledged that conducting surveys is costly and, for practical reasons, in some countries, wages are still used as an indicator of time value.

The calculations in current study are based on the value of Heacto's recommended time plus one-third due to GDP growth during last ten years. Thus, the monetary value of one hour leisure time used in the following calculations is equal to 6.5 €.

3.3.7.3.2 Monetary valuation of ecosystem recreational service based on time value

Estonia has an extensive system of hiking and health trails. Many trails are equipped with counters that give an indication of the number of visitors. Based on expert opinion the average time it takes to get to and from the trail and time spent on-site is known which allows to evaluate the ecosystem recreational service based on the time spent by visitors.

Considering the population density in Estonia, hiking and exercise and sports tracks (so called health trails) can be divided into two categories: those in densely populated areas (urban) and those in less densely populated areas (nature). In the case of urban health trails, the time taken to get to and from the trail is one hour, plus the time spent on the trail is 0.5 hours. So the average time spent on one visit is 1.5 hours, which equals 9.75 € in monetary terms (6.5 €/hour). The duration of one visit to trails which are in nature is considerably longer. For nature trails, it takes a total of 3 hours for a visit (1.5 hours at one end) and an average of two hours on the trail. Thus, in the case of nature trails, the average time spent per visit is 5 hours, with a monetary value of € 32.5.

In case, when the recreational value of ecosystems is calculated only using the time spent in contact with nature (excluding travel time), the average time based monetary value per visit is 3.25 € (0.5 h*6.5 €) for urban trails and 13 € (2 h* 6.5 €) for nature trails.

The majority of Estonian nature trails and health trails are managed by two different organizations, The State Forest Management Centre (hereafter SFMC) and Estonian Health Trails Foundation. All the tracks

[75] Tiehallinto. (2005), Tieliikenteen ajokustannusten yksikköarvojen Määrittäminen, Tervonen, J., Ristikartano, J, & Penttinen, M-M., Taustaraportti 2005, Sisäisiä julkaisuja 48/2005, Tiehallinto, Helsinki 2005. [WWW] http://alk.tiehallinto.fi/julkaisut/pdf/4000485-vtieliik_ajokust_yksikkoa.pdf

[76] Heatco. Developing Harmonised European Approaches for Transport Costing and Project Assessment. Deliverable 5 Proposal for Harmonised Guidelines. (2006). [WWW] http://heatco.ier.uni-stuttgart.de/

managed by SFMC are in nature, trails managed by Estonian Health Trails Foundation are located both in nature and urban areas.

According to the SFMC estimations (based on electronical counters information), 2.7 million people crossed the nature trails which were managed in 2018. Multiplying the total number of visitors by the value of one visit (€ 32.5), the result is approximately € 88 million per year.

Without travel time, the time based recreational value, calculated on the bases of SFMC nature trail visitors is approximately 35.1 million (13 €* 2.7 million visitors)

0.59 million people visited the trails which are managed by the Estonian Health Trails Foundation in nature areas and 2.58 million people visited the trails in urban areas. The total value of time spent for visits (travel time included) to nature trails which are managed by the Estonian Health Trails Foundation is € 20.9 million (32.5 € x 0.59 million visitors) and to trails in urban areas € 25.2 million (2.58 million visitors x 9.75 €). Thus, the total time spent on the tracks managed by the Estonian Health Trails Foundation is € 46.1 million (20.9 + 25.2) per year.

The time based value of recreational service without travel time considering only nature trails which are managed by the Estonian Health Trails Foundation is € 7.7 million (13 € x 0.59 million visitors) and to trails in urban areas € 8.4 million (2.58 million visitors x 3.25 €).

Adding up the total time spent on the tracks which are managed by the SFMC and the Estonian Health Trails Foundation, we get 134 million with travel time and 51 million € without travel time.

Thus, using the time value 6.5 €/hour, the annual value of the ecosystem recreational service in Estonia is estimated to be 134 million € which includes travel time and 51 million € which excludes travel time.

In total, we estimated the value of recreational ecosystem service by three methods: expenditures approach and time use values (two variations). Therefore, we had to choose one of the methods for the purposes of calculation of the total service values. Considering methodological recommendations from our project expects, it seemed reasonable not to include travel time in the calculations when estimating the value of recreational ecosystem service based on time.

3.3.7.4 Spatial analysis

Information about nature recreation sites spatial data was first collected (see below) and mapped, in order to find annual value of nature recreation as ecosystem service, which was related specifically to grasslands. In spatial analyses every site or trail that provides nature recreation ecosystem service was buffered with 500m to account with areas/ecosystems that support nature recreation service at site but does not necessarily intersect with the site/trail directly.

3.3.7.4.1 Data for nature recreation ecosystem service

Acquired spatial data for the valuation of nature recreation as ecosystem service consisted:

a) Spatial data for health trails in Estonia (provided by NGO SA Eesti terviserajad)
b) Spatial data for recreation areas which are managed by the SFMC

a) The health trails related to the provisioning of recreation service was obtained from webpage *terviserajad.ee* which both needed to be separately digitized and/or corrected. Terviserajad.ee is a private (sponsored) NGO that manages and maintains more than a hundred health tracks in different parts of Estonia. The trails are mainly located at the state land. They also keep track of attendance, using counters in a few dozen tracks. For the remainder of the trails, the number of visitors were estimated by experts from SA Eesti terviserajad. Initially spatial data was received as polyline type of data which we converted to polygon type of data by additionally creating buffer zones of up to 20m. After conversion, we created buffers with radii of 500m around the polygons to account with areas/ecosystems that support nature recreation service at the site but does not necessarily intersect with the site/trail directly.

b) Data for recreation areas from the State Forest Management Centre was initially obtained as polyline, point and polygon data, which were converted (line, point) to polygons by creating buffers with radii of 500 m around the objects. This was necessary to account with areas/ecosystems that support nature recreation service at the site but does not necessarily intersect with the site/trail directly.

3.3.7.4.2 Ecosystem recreation service value allocation between ecosystem types

By overlaying the ecosystem unit base map and nature recreation sites/trails data (buffers), we calculated the share (area) of each ecosystem type in the recreational areas. We divided the total recreation service value between ecosystem types according to the share of each area of ecosystem type in polygons. This, rather simple method, to divide values equally over the recreation service providing area was suggested by the project experts. It was suggested that in future the allocation can be improved and the recreation service area, where most of the service is actually provided (places which people visit more often) could be taken into account either in respect to specific polygons or on a more aggregate level.

The values of the grasslands ecosystem service of providing recreational services are shown in Table 29. The contribution of the grassland ecosystem to the recreational ecosystem service is 5.3 million based on time use approach (excluding travel time), 3.1 million of which is provided by the semi-natural grasslands and 2.2 million by cultivated grasslands.

As can be seen from the results in Table 30, both semi-natural (58% of the total) and cultural (42% of the total) grasslands are rather well represented in polygons which were formed around nature- and health trails. Noteworthy is the relatively high proportion of cultivated grasslands and the rather modest representation of grasslands which are at the Natura sites (26% of total). This shows that the cultural grasslands have equal recreational value compared to the semi-natural ones, but also that the potential of grasslands at Natura sites are largely unused for recreation ecosystem service. Northern boreal alluvial meadows have the highest recreational ecosystem service value (€ 0.6 million per year without travel time) among the grasslands having Natura code, forming almost half of the total value of the respective group. Visualization of the service provisioning areas and values of recreation service of Estonian grasslands can be seen in Figure 9.

Table 30. Provision of recreational ecosystem service by grasslands types, 2018, €

Ecosystem type/method	Time use method excl travel time	Time use method Incl travel time	Expenditure method
Grasslands total	5 312	13 958	750
Semi-natural grassland	3 070	8 065	433
Semi-natural grassland according to the NATURA classification	1 374	3 610	194
Boreal baltic coastal meadows	163	427	23
Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	20	53	3
Inland dunes with open Corynephorus and Agrostis	0	0	0
European dry heaths	22	57	3
Juniperus communis formations on heaths or calcareous grasslands	23	59	3
Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	69	182	10
Fennoscandian lowland species-rich dry to mesic grasslands	101	266	14
Nordic alvar and precambrian calcareous flatrocks	77	202	11
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	22	59	3
Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	69	181	10
Northern boreal alluvial meadows	625	1 641	88
Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	124	326	18
Fennoscandian wooded meadows	45	117	6
Fennoscandian wooded pastures	15	40	2
Other grassland	1 695	4 455	239
Cultivated grassland	2 235	5 873	316
Permanent grassland	2 235	5 873	316
Environmental non-sensitive permanent grassland	2 228	5 854	315
Environmental sensitive permanent grassland	7	19	1

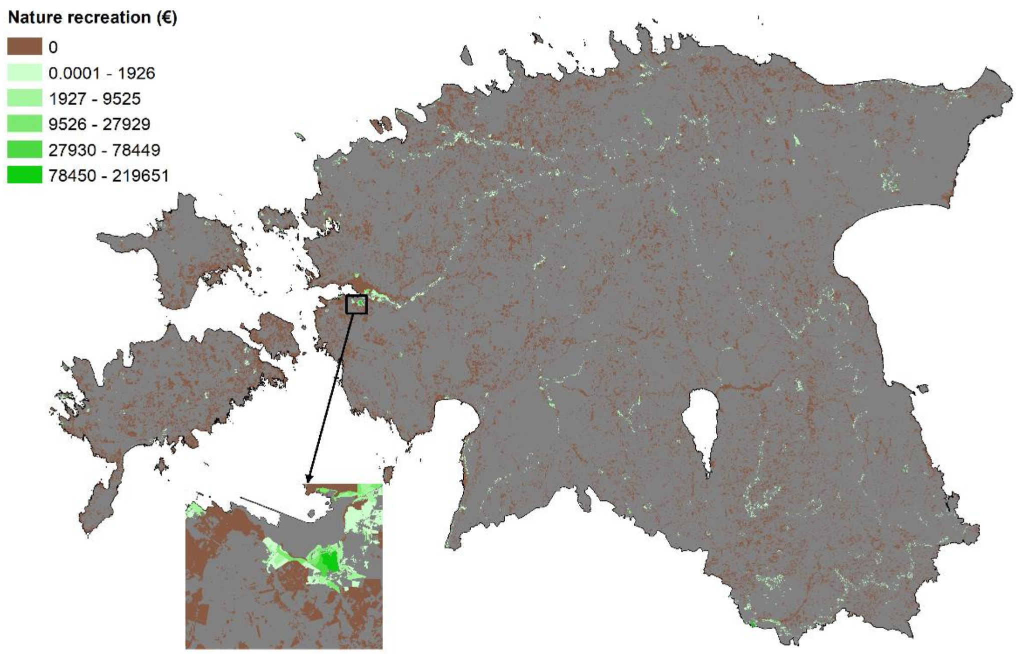

Figure 9. The ecosystem service provisioning areas and values of recreation ecosystem service of Estonian grasslands. The areas coloured in the scale from brown to green represent grasslands according to the value they supply the service that was calculated using time use approach. The values shown correspond to the total value of ecosystem service per grassland type. Dark grey areas are other ecosystem types that were not analysed in the current work.

3.3.7.5 Conclusions

There are several popular recreational activities that were not included in the assessment of nature recreation as ecosystem service valuation due to the scarcity of data, such as hiking outside SFMC trails or health tracks, cycling, water sports, seashore activities, outdoor sports, recreational fishing, etc. These other specific recreational activities will be looked into in the future and methods (consumer expenditures, travel cost method) to assess the monetary value of these ecosystem service will be considered. Assessing aesthetic recreational services was also considered as important but it was concluded that it was too difficult to say what exactly the transaction in these activities is.

It was discussed in a project group that the value of the recreation ecosystem service depends largely on the input data. To get more accurate results, there is a need to fill the caps in statistics about leisure activities because Statistics Estonia does not have a detailed record of leisure activities or tourism in official statistics currently.

It was suggested by project experts to look at tourism resource rent methodology in the future as well. The issue of defining what the ecosystem service is actually contributing to the output of tourism industry is quite complex, it needs more analysis. It is also important to analyse the overlap of the results obtained by different methods.

3.3.8 Recreational hunting

The ecosystem service is hunting wild game. The ecosystem service of hunting is closely related to the provisioning of game as the latter is a prerequisite for the first. Providing game is considered as a provisioning ecosystem service whereas hunting is a recreational activity under cultural ecosystem services. People (hunters) are often involved in hunting for both purposes and these interests often overlap. Therefore it is difficult to determine under which category the service of provisioning of game/hunting falls or how to divide it into shares.

In the selection of suitable methods to assess the value of the ecosystem service of provisioning of game/hunting we considered following approaches:

1. Provisioning of game as a provisioning service
2. Hunting as a cultural service

These two approaches characterize two different aspect that the asset provides, therefore it is possible to add the provisioning and recreational value of game/hunting when overlapping part is first determined.

3.3.8.1 Definition of the recreational hunting ecosystem service

The cultural ecosystem service of hunting is defined as the physical interaction of the hunter with the natural environment due to the presence of game in the said natural environment. It can be considered as a recreational activity. According to CICES V5.1 it is defined under code 3.1.1.1: The biophysical characteristics or qualities of species or ecosystems (settings/ cultural spaces) that are engaged with, used or enjoyed in ways that require physical and cognitive effort (Table 31). The beneficiaries and users of the service are households.

Table 31. Definition of the ecosystem service of recreational hunting according to CICES v5.1

Class	**Code**	**Simple descriptor**	**Ecological clause**	**Use clause**	**Example Service**	**Example Goods and Benefits**
Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	*3.1.1.1*	*Using the environment for sport and recreation; using nature to help stay fit*	*The biophysical characteristics or qualities of species or ecosystems (settings/ cultural spaces)….*	*…. that are engaged with, used or enjoyed in ways that require physical and cognitive effort*	*Ecological qualities of woodland that make it attractive to hiker; private gardens Or Opportunities for diving, swimming*	*Recreation, fitness; de-stressing or mental health; nature-based recreation*

3.3.8.2 Methods and data

Hunting is an activity that requires very specific equipment and licences. Therefore we can consider that the expenditure a hunter makes with the purpose to engage in the activity is the expenditure made to use the ecosystem service recreational hunting and we can consider the consumer expenditures as a marginal value of the ecosystem service.

Name of the dataset	**Data type**	**Source**
Hunted game 2018/19	Statistics	Estonian Environment Agency
Value and cost of hunting, 2016	Literature	Michl Ebner (FACE). The economic value of hunting in the EU. Presentation. 2016
Map of hunting districts in Estonia	Spatial Data	Estonian Environment Agency
Ecosystem unit map	Spatial data	Statistics Estonia

Hunting in Estonia is regulated so that every hunter who wishes to hunt needs to have a valid hunting licence and pay a yearly fee for hunting rights. Expenditures to obtain a hunting licence include specific schooling and taking exams, but this is a one-time process and statistics about these are difficult to acquire. A hunter needs to pay a yearly fee for hunting rights which is 10 € per year.

To widen the scope, we included other expenditures a hunter makes. No suitable data was found in Estonia but using benefit transfer method we adapted the data about the average yearly expenditures of German hunters in 2016[77] for Estonian context in 2018 by applying purchasing power standard (Table 32). According to expert opinion, there is no need to consider lease of a hunting ground which is the biggest contributor for the overall expenditure for a hunter in Germany as an expenditure for a hunter in Estonia due to differences in hunting systems so we excluded the expenditures made for leasing from our calculations.

Table 32. Cost of hunting in Germany and Estonia, € in PPS, 2018

Value and cost of hunting	**Annual average expenditure Germany, 2016 (€)**	**Annual average expenditure Estonia, 2018 (€)**
Lease /possibility to go hunting.	1570	-
Car and infrastructure	910	396
Area facility (e.g. high seats)	520	226
Tools (weapons, knives)	390	170
Hunting clothes	280	122
Game damage / bite protection	270	117
Habitat management / biodiversity	220	96
Other (dog, material)	180	78
Average annual expenditure per hunter	4340	1205

3.3.8.3 Results

In the narrow scope we calculated the value of the service on the basis of yearly hunting fees. This is 134 thousand € per year (Table 33).

Table 33. Expenditure costs of hunting in Estonia (narrow scope), 2018, €

Number of hunters	Yearly fee for hunting rights, €	VALUE of the ecosystem service, €
13370	10	133 700

In the wide scope, we calculated the value of the ecosystem service on the basis of annual average expenditure per person. This is approximately 16.1 million € per year. Adding the yearly fee of hunting rights as an expenditure, the value of the recreational hunting service is 16.2 million €/year (Table 34).

[77] Michl Ebner. The economic value of hunting in the EU. Presentation. 2016

Table 34. Expenditure costs of hunting (wide scope), 2018, €

Number of hunters	Annual average expenditure per hunter. Estonia, 2018 (€)	VALUE of the ecosystem service, €
13370	1205	16 110 850
13370	10	133 700
TOTAL		16 244 550

3.3.8.1 Spatial analysis

The distribution of the ecosystem service value of recreational hunting was approached similarly to the provisioning of game/hunting. We used top-down approach for calculating the ecosystem service value for different ecosystem types as it was difficult to distinguish which ecosystem type provides the service as different game species roam in a wide area and often prefer mosaic landscape where different ecosystem types are present as a habitat.

First we calculated the value of the hunting service for the whole country by hunting districts. Then by overlaying the ecosystem unit map and hunting district map (does not cover 100% of the area of Estonia, excluding settlements for example) we obtained the share (in area units) of each ecosystem type in the hunting district. Including all natural and vegetated ecosystems (excluding waterbodies, rocky slopes and artificial landscapes), we divided the service value per hunting district between ecosystem types according to the area of ecosystem type (service *value per hunting district*area of the ecosystem type/area of all ecosystem types present in the hunting district*).

From the spatial analyses (overlaying) obtained dataset of ecosystem service values for ecosystem types it was possible to derive the values of the ecosystem service of recreational hunting for different grassland types which are shown in Table 35. The contribution of the grassland ecosystems to the hunting ecosystem service is 2.2 million €/year of which 1.1 million €/year is provided by semi-natural grasslands.

Visualization of the service provisioning areas and values of hunting ecosystem service of Estonian grasslands can be seen in Figure 10.

Table 35. Values of the ecosystem service of recreational hunting by grassland types, 2018, €

Grassland type	**Value (€/year)**
Boreal baltic coastal meadows	110 982
Fixed coastal dunes with herbaceous vegetation ("grey dunes")	1 460
Dry sand heaths with Calluna and Empetrum nigrum	220
Inland dunes with open Corynephorus and Agrostis	122
European dry heaths	2 095
Juniperus communis formations on heaths or calcareous grasslands	24 256
Xeric sand calcareous grasslands	166
Calaminarian grasslands of the Violetaliacalaminariae	2
Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	28 434
Fennoscandian lowland species-rich dry to mesic grasslands	24 326
Nordic alvar and precambrian calcareous flatrocks	97 956
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	15 350
Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	14 972
Northern boreal alluvial meadows	90 094
Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	19 736
Fennoscandian wooded meadows	22 626
Fennoscandian wooded pastures	17 036
Other semi-natural grassland	598 270
Environmental non-sensitive permanent grassland	1 150 913
Environmental sensitive permanent grassland	2 580
TOTAL	2 221 598

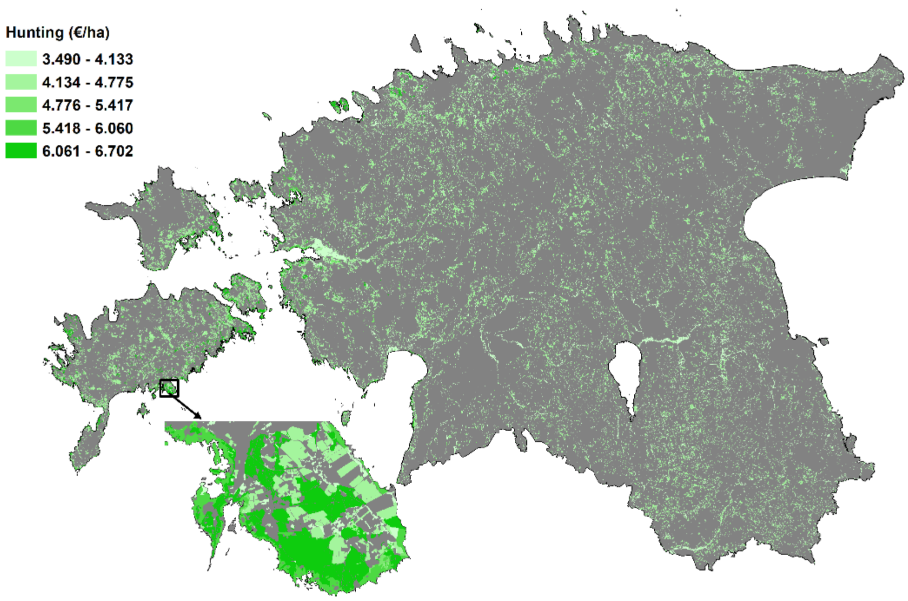

Figure 10. The ecosystem service provisioning areas and values of hunting ecosystem service of Estonian grasslands. The areas coloured in shades of green represent grasslands according to the value they supply the service that was calculated using wide

scope of expenditure costs approach. The values shown correspond to the total value of ecosystem service per grassland type. Dark grey areas are other ecosystem types that were not analysed in the current work.

3.3.8.2 Conclusion

The ecosystem service value of recreational hunting was calculated using cost based (consumer expenditure) approach. We considered a narrow scope of expenditures made by a hunter that included only purchase of hunting fee and a wider scope which tried to incorporate all the expenditures a hunter may make to go hunting.

Using hunting statistics of users of a hunting district by hunting districts and average as well average annual expenditure of the value which was calculated and then distributed across ecosystem types. Based on the calculations, the total value of ecosystem service of recreational hunting by different grassland types is 2.2 million €/year of which 1.1 million €/year is attributable to semi-natural grasslands. When including all contributing ecosystem types in Estonia, the ecosystem service value was estimated to be 16.2 million €/year.

How to find the share of the contribution of the ecosystem in the calculated value of recreational hunting is still under discussion. It was recommended to consider the whole calculated value of recreational hunting service as the contribution of the ecosystem but as with other cultural ecosystem services a person’s presence is needed to provide the service.

Additional problems that arose during assessment of the service were related to incomplete input data and determining which ecosystem types actually contribute to the provisioning of game in sense of which ecosystem types hunters visit more and which are the most suitable habitats for game species. The data of annual average expenditure per hunter used in benefit transfer method should be also revised to better reflect real expenditures Estonian hunter actually makes. These problems will be looked into in the next phase of the project and now knowing the needs, we will work on improving the assessment methodology.

Adding the obtained values of the two ecosystem services: provisioning of game and recreational hunting was also suggested by project experts when double counting can be eliminated. The only shared part in the valuation of the service from the aspects of both approaches is the expenditure for hunting fees. For all Estonian ecosystem types the total value of the ecosystems services related to wild game is approximately 24.6 million €/year. However, in the current assessment we decided to keep the provisioning and cultural services related to hunting separate.

Providing game	8 493 551
Expenditure for hunting (without expenditure for hunting fees)	16 110 850
TOTAL (€/year)	24 604 401

3.3.9 Nature education service

3.3.9.1 Description of the service: Definition and the scope of the nature education service

Can nature education be regarded as an ecosystem service? It may be argued that nature education is a service provided by society for the benefit of society and hence not something which ecosystems contribute a value to. However, we suggest that the ability of the ecosystem to contribute to the supply of nature education service is an important feature and the estimated value of the service could be useful in decision making in planning processes when developing areas of interest. Despite the difficulties with definitions and assessment, the comparability and consistency with the valuation of other ecosystem services (provisioning, regulating and other cultural services) and ultimately the spatial distribution of the use of the service is desirable.

Nature education is one of the many services that ecosystems provide to societies as a cultural service. Whereas valuation methods for several ecosystem services are already well-developed, not much attention has been paid to nature education as an ecosystem service. Also System of Environmental-Economic Accounting –Experimental Ecosystem Accounting (SEEA EEA)[78] and methodological guidebook "Technical Recommendations in support of the SEEA EEA 2012 (SEEA EEA TR)"[79] do not provide clear guidelines and recommendations on the topic. Therefore, several questions regarding the definition, scope and methods for quantification of this service need to be considered.

Several studies, for example Böhnke-Henrichs et al. (2013)[80] and Fish et al. (2016)[81] conclude that ecosystems are contributing just partially to the provisioning of cultural services (including educational) and that the challenge is to single out the part of the service that ecosystem contributes. An empirical framework provided by Fish et al. emphasizes that the ecosystem plays the role of the "enabler" and society plays the role of the "shaper" in supplying cultural ecosystem services[82]. The framework is presented in Figure 11. This framework explains how to incorporate distinctive contributions of society and ecosystems in case of cultural (including nature education) ecosystem services. This ecosystems based approach supports both the conceptual complexity and varying geographical contexts. The framework is distinguished by its emphasis on the co-production and reciprocity of culture-nature relationships.

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[78] UN, EU, FAO, IMF, OECD and World Bank (2014) System of Environmental-Economic Accounting 2012: Experimental Ecosystem Accounting. New York, https://seea.un.org/sites/seea.un.org/files/seea_eea_final_en_1.pdf

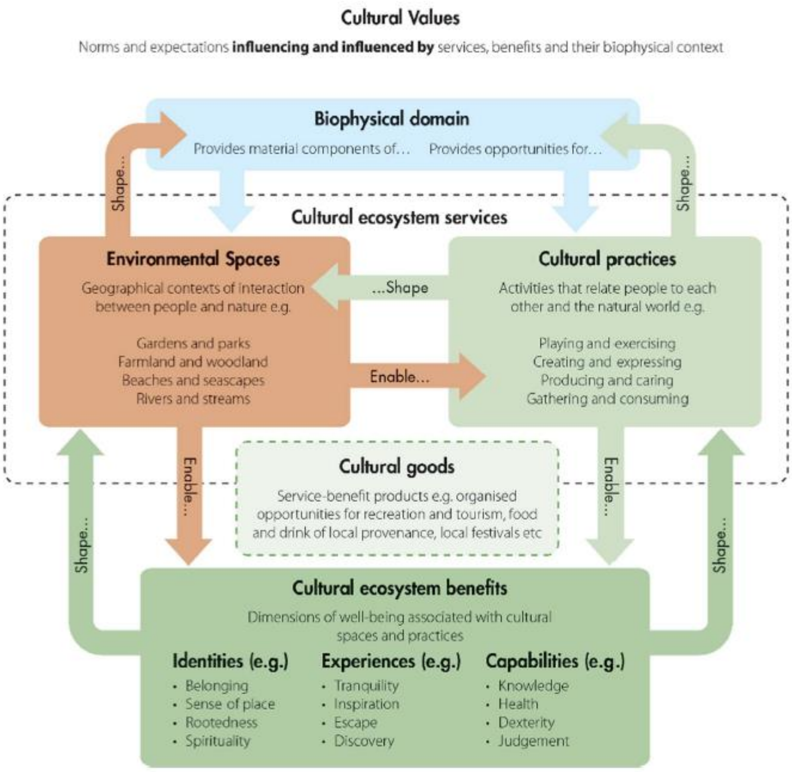
[79] UN (2017) SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft. New York, USA. https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

[80] Böhnke-Henrichs, A., Baulcomb, C., Koss, R., Hussain, S.S., de Groot, R.S., 2013.Typology and indicators of ecosystem services for marine spatial planning and management. J. Environ. Manage. 130, 13–145, http://dx.doi.org/10.1016/j.jenvman.2013.08.027

[81] Fish, R., Church, A., Winter, M., 2016 Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. Ecosystem Services, Volume 21, Part B, 2016, Pages 208-217, ISSN 2212-0416, https://doi.org/10.1016/j.ecoser.2016.09.002

[82] Ibid

Figure 11. Incorporation the distinctive contributions of society and ecosystems in case of cultural (and also education) ecosystem services. Source: A conceptual framework for cultural ecosystem services, Fish et al. (2016)



We analysed the literature, specifically looking for studies where the distinction between ecosystem service provisioning potential and actual supply of ecosystem services. The illustrative ecosystem service potential and real flow matrices were well described in a study by Burkhard et al. (2014)[83]. The illustrative valuations refer to a hypothetical European “normal” landscape valued in a five points scale.

Mocior and Kruse[84] propose to distinguish between the values and the services in the case of nature education service. More precisely “educational values” have been seen as a potential of landscapes and ecosystems to provide the education service (i.e. opportunities for formal and informal nature education) and the ecosystem service flow reflects the real usage of landscape and ecosystems for educational purposes. This study gives a good overview of the definitions of various educational values of landscapes and ecosystems, proposes useful criteria for the valuation analysis of nature education potential of nature areas and for classifying them into separate groups/classes according to the potential to provide education service.

[83] Burkhard, B., Kandziora, M., Hou, Y., Müller, F., 2014. Ecosystem service potentials, flows and demands – concepts for spatial localisation, indication and quantification. Landsc. Online 34, 1–32, http://dx.doi.org/10.3097/LO.201434

[84] Mocior, E. & Kruse, M. (2016). Educational values and services of ecosystems and landscapes – An overview. Ecological Indicators. 60. 137-151. http://dx.doi.org/10.1016/j.ecolind.2015.06.031

Regarding valuation methods relevant for the valuation of nature education service, there is a study regarding the educational values of ecosystems by Hutcheson et al, 2018[85] which uses travel cost method approach and covers a large number of students and one specific park (Hudson River Park) where environmental education programs were held by schools and summer camps. However, it is difficult to apply this approach in our case as we have an opposite situation: a lot of "parks"/sites and not so many students per park/site.

A recent study by Vallecillo et al. (2019)[86] discusses valuing nature-based short-distance recreation service in biophysical and monetary units. Recreation and nature education are both cultural services and the flow of the service from ecosystems to people is similar. In this study, first the ecosystem recreation service potential was derived from ecosystem-based potential, then the population's demand for the service based on the distance between the supply (considering only high-quality recreation service areas) and demand locations was modelled. The actual flow assessment and monetary valuation was done by applying a zonal travel cost method where travel expenses by car (cost of fuel) were used as an exchange price. The actual flow of the ecosystem service was allocated between ecosystem types depending on the relative extent of ecosystems within the area suitable for recreation.

We also looked SEEA EEA guidelines[87], regarding the SNA approaches to valuing non-monetary transactions where market prices are not observable like the production of education and health services by government. Valuation according to market price equivalents provides a procedure for use, namely the cost of production approach, in which the value of the non-monetary transaction is deemed to be equal to the sum of the costs of producing the good or service, that is the sum of intermediate consumption, compensation of employees, consumption of fixed capital (depreciation), other taxes (less subsidies) on production, and a net return on capital[88].

UN SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft[89] suggests that in case of nature education service in biophysical terms, all services and benefits can be measured in terms of the number of people engaging in such activities.

We have been discussing with an expert group whether it would be reasonable to try to capture the future value of nature education in monetary terms. Taking an example from education economics, UN SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft for an example from education economics (UN SEEA EEA TR, Chapter 6. 22, 6.23) suggests to valuate nature education services as a contribution of environmental education to the future benefit or income.

[85] Hutcheson, W., Hoagland, P., Jin, D., 2018. Valuing environmental education as a cultural ecosystem service at Hudson River Park. Ecosystem Services, Volume 31, Part C, 2018, Pages 387-394, ISSN 2212-0416, https://doi.org/10.1016/j.ecoser.2018.03.005.

[86] Vallecillo, S., La Notte, A., Zulian, G., Ferrini, S., Maes, J., 2019. Ecosystem services accounts: Valuing the actual flow of nature-based recreation from ecosystems to people, Ecological Modelling, Volume 392, 2019, Pages 196-211, ISSN 0304-3800, https://doi.org/10.1016/j.ecolmodel.2018.09.023.

[87] UN, EU, FAO, IMF, OECD and World Bank (2014) *System of Environmental-Economic Accounting 2012: Experimental Ecosystem Accounting*. New York, USA, pages 144-145.

[88] UN (2008) System of National Accounts 2008 - 2008 SNA, para. 6.125. https://unstats.un.org/unsd/nationalaccount/sna2008.asp

[89] UN (2017) *SEEA Experimental Ecosystem Accounting : Technical Recommendations Consultation Draft*. New York, USA, pages 10000.

Also, in UN SEEA TR the question for discussion and investigation is whether a complementary set of ecosystem accounts in monetary terms might be compiled using non-exchange value concepts, namely so called welfare values also in case of nature education. The starting logic was that complementary accounts could be based on the same biophysical accounts (for ecosystem extent, condition and service flows) and then alternative valuation concepts that would include consumer surplus could be applied to support particular policy contexts. The feasibility and relevance of such an approach has been debated using the example of the nature education service in the expert group working on grant.

Depending on the policy or decision-making context there seems to be a need for both: presenting exchange-based and welfare-based values. Willingness to pay method has supported policy analysis and decision making in Estonia for some time now. The contingent valuation method has so far been applied, for example, to determine the monetary equivalent of the values for Jägala waterfall (Ehrlich, Ü, Reimann, M, 2010[90]), shores in natural condition (Reimann, M, Ehrlich, Ü, 2012[91]) and biological habitats (Lepasaar, H, Ehrlich, Ü, 2015[92]).

UN SEEA EEA TR stipulates that values recorded in the national accounts for the production and consumption of education do not reflect the full welfare arising from this consumption. We are aware that currently in the national accounts monetary values does not reflect all generated welfare related to the value of nature education service provided by ecosystems. The use of exchange values to underpin macro-economic measurement and modelling is accepted by UN SEEA TR, as is the relevance of estimating welfare values in making decisions, for example in the assessment of costs and benefits for additional investments in the education system. [93]

The incurred expenditure method is an indirect method of economic valuation of non-market goods and the values are based on revealed preference. Finding the monetary value of ecosystem education services through the spending of institutional education is based on the assumption that general education is a public service aimed for creating and improving the quantity and quality of human capital. We are not able to value the increase of human capital (due to nature education being an abstract concept and public goods) directly but we assume that the value of education is at least as large as expenditures made to obtain it.

The exchange- and welfare-based valuations will be described in subsections of chapter “Nature education as ecosystem service, valuation”. The values recorded may have important deviations depending on the methods chosen and assumptions made.

Discussion paper 5.1 “Defining exchange and welfare values, articulating institutional arrangements and establishing the valuation context for ecosystem accounting” prepared by the experts as part of the

[90] Ehrlich, Ü, Reimann, M. 2010. “Hydropower versus Non-market Values of Nature: a Contingent Valuation Study of Jägala Waterfalls, Estonia. International Journal of Geology. 2010. a., Kd. 4, 3.
[91] Reimann, M, Ehrlich, Ü. 2012. Public Demand for Shores in Natural Condition: a Contingent Valuation Study in Estonia. International Journal of Geology. 2012. a., Kd. 6, 1
[92] Lepasaar, H, Ehrlich, Ü. 2015. Non-market value if Estonian semi-natural grasslands: a contingent valuation study. Estonian Discussion of Economic Policy. 2015. a., Kd. 23, 2
[93] UN SEEA EEA TR, 6.23

work on the SEEA EEA Revision coordinated by the United Nations Statistics Division[94] was considered useful in order to analyze the meaning and comparability of the results of applied methods and related values. The suggestion that actual costs of management based on exchange values would constitute a lower bound for service value while maximum willingness to pay constitute an upper bound, was considered relevant.

The following chapter presents the definition of the scope and development for the concept in the current work on natural education ecosystem service by Statistics Estonia.

3.3.9.2 Definition and the scope of the nature education service

In the Common International Classification of Ecosystem Services (CICES) version 5.1 (Haines-Young and Potschin, 2018)[95], the education service is included within the ecosystem service defined as "information and knowledge".

Table 36. Environmental education is classified under the cultural ecosystem services according to CICES V5.1.

CICES Code	Section	Division	Group	Class	Class type
3.1.2.2	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable education and training	By type of living system or environmental setting

According to the ecological use clause in CICES definition: "The biophysical characteristics or qualities of species or ecosystems settings/cultural spaces that are the subject matter for in-situ teaching or skill development" environmental/nature education service is limited to *in situ* nature education service. The example service could be "site used for voluntary conservation activities" and the example of goods and benefits "studying nature, skills or knowledge about environmental management".

Based on the CICES classification the project group has agreed on a following definition: "The value of the ecosystem as an educational service provider is expressed by its ability to participate in nature education." The important criteria for the inclusion of the activity as an education service is the direct association of the educational activity with the natural ecosystem.

In the current work the operational definition i.e. metric was decided to be the actual volume of nature education provided by the (specific) ecosystem (area object) in biophysical and monetary units.

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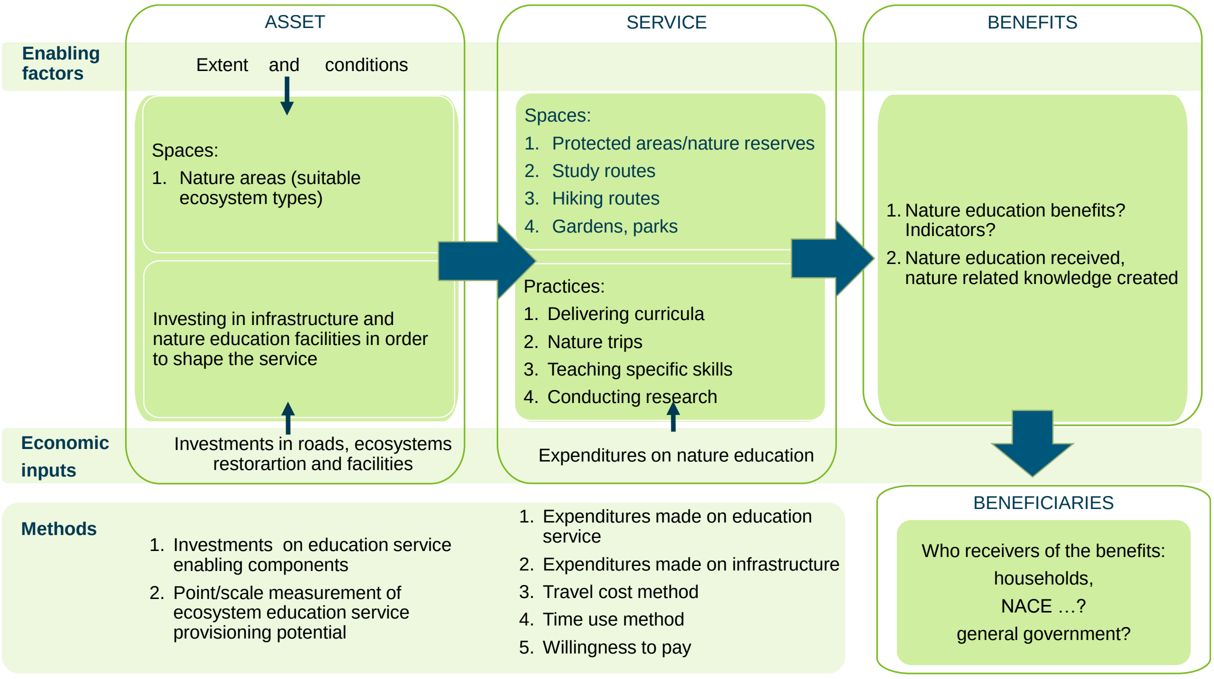
[94] Barton D.N., Caparrós A., Conner N., Edens B., Piaggio M., Turpie J. (2019). Discussion paper 5.1: Defining exchange and welfare values, articulating institutional arrangements and establishing the valuation context for ecosystem accounting. Paper drafted as input into the revision of the System on Environmental-Economic Accounting 2012– Experimental Ecosystem Accounting. Version of 25 July 2019. https://seea.un.org/sites/seea.un.org/files/documents/EEA/discussion_paper_5.1_defining_values_for_erg_aug_2019.pdf

[95] Haines-Young, R. and M.B. Potschin (2018):Common International Classification ofEcosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Available from www.cices.eu

The ecosystem component was restricted to the nature education service provided directly in the ecosystem (i.e. the process of theoretical and practical learning of the relevant nature studies in which the information obtained from the ecosystem is involved). An indirect use, such as visiting a biodiversity/ natural history museum is excluded from the scope.

The agreed scope of nature education service includes institutionally organized nature education, self-learning is not included. The distinction between formal nature education (e.g. during school classes) and informal or private nature education is not made. The framing of the scope and dimensions of the service is based on the concept of Fish et al[96] and is adapted for nature education service. The scheme of the service is presented on Figure 12.

Figure 12 Conceptual scope of the service (compiled based on the project working group discussions)



Classification of spatial units relevant for nature education service was developed on the basis of the correspondence to the following criteria: 1) area is used for educational purposes and 2) area is mappable. The identified spatial units relevant for nature education service are shown in Table 37 and the activities that are related to the provisioning of nature education are displayed in Table 38.

Table 37. Spatial units relevant for nature education service

Spatial units that are relevant for provisioning nature education
SFMC recreational areas with study opportunities (three subclasses according to NATURA and protection level)
SFMC nature education program areas (three subclasses according to NATURA and protection level)
Nature education centres (three subclasses according to NATURA and protection level), Environmental Board
Nature education centres, other
Study trails; hiking routes with educational purpose
School gardens, parks; used for education
University study centres, field bases
Other nature (three subclasses according to NATURA and protection level)

[96] Fish et al. (2016)

SFMC (State Forest Management Centre) recreational areas with study opportunities and SFMC nature education program areas were further subdivided into three subclasses in order to distinguish their educational potential according to their location on Natura areas and other local protected areas. It is assumed that the potential education quality is higher in protected areas and lower in the areas that are not protected.

Table 38. Activities that are related to the provisioning of nature education in situ

Activities that are related to the provision on nature education *in situ*
Designing and delivering nature related curricula in nature
Creating study materials and learning environments
Nature trips
Outdoor school lessons
Providing specific skills
Providing expertise
Conducting research and creating knowledge

3.3.9.3 Evaluation of nature education sites on the potential educational values

If in general, the wider goal is to get the total monetary value of all relevant ecosystem services provided by any area, the approach for service valuation should be fully spatial. In order to get the spatial dimension, it is necessary to spatially valuate (model) the (potential) supply of the service and also the use of the ecosystem service.

Spatial units relevant for nature education service were assessed based on their potential educational values. Criteria for the assessment of the potential educational values of spatial units and the indicators for the quantification of the ecosystem education services on the basis of the reviewed literature (main input from Mocior & Kruse[97]) were analysed and a set of criteria were agreed based on project group expert opinions. Table 39 outlines nature education values of spatial units relevant for nature education as ecosystem service and the assessment of importance. At first the relevance of the criteria of potential educational values was assessed on a three points scale by the project team. The assessment of agreed criteria is based on the current knowledge of the working group and should be treated as such. In our opinion ecosystem education values ask for a universal national level agreed criteria and assessment in future.

[97] Mocior & Kruse (2016).

Table 39. Criteria of nature education values of spatial units relevant for nature education service and the assessment of importance. Importance score: 2- precondition for provisioning of educational services; 1- important; 0- not important.

Criteria for the evaluation of the didactic value of nature sites	**Importance**
A. With regard to educational value	
1. Use for educational purposes	2
2. Availability of infrastructure for access	2
3. Supporting educational products and services (maps, information materials, printable, website)?	1
4. Existing learning infrastructure products (signposts, trails, boardwalks, information boards)	1
5. Approval for educational use	0
B. Criteria for defining scientific and didactic value:	
1. Rarity (ecosystem, landscape type), I, II and III category species' permanent habitat	1
2. Representativeness (ecosystem, landscape type), belongs to national parks, landscape protection areas	1
3. Diversity (the composition of different ecosystem types, species), national reserves	1
4. Level of scientific knowledge, monitoring sites	1
5. Useful for describing ecosystem processes	1
6. Paleo geographic value	0
7. Recognition	0
C: Criteria for other educational significance	
1. The protected area is part of major tours and routs	0
2. Recognition	0

On the basis of the used criteria, a matrix (Table 40) was compiled which outlines the values of the components of education service value to each spatial unit relevant for nature education service. The matrix could serve as a lookup table for potential capacity for evaluation of nature education ecosystem service.

Table 40. Categorization of spatial units relevant for nature education ecosystem service by the nature education value.

Nature education provisioning sites /Dimension of educational value	Site specification	Educational products and services	Learning Infra-structure, products	Rarity	Representativeness	Diversity	Scientific knowledge	Ecosystem processes	Use rate
Scale		0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-10
SFMC: recreational areas with study opportunities									
	Located fully on NATURA or other protected areas	5	3	4	4	4	3	4	10
	Located partially on NATURA or other protected areas	5	3	3	3	3	2	3	10
	Not located on NATURA or other protected areas	3	2	1	1	2	1	2	10
SFMC: nature education program areas									
	Located fully on NATURA or other protected areas	5	5	4	5	4	3	4	7
	Located partially on NATURA or other protected areas	4	5	3	4	3	2	3	7
	Not located on NATURA or other protected areas	3	5	1	2	2	1	2	7
Nature education centres, Environmental Board		5	4	4	4	3	3	4	6
Nature education centres, other		5	4	4	4	3	2	4	TBA
Hiking routes with educational purpose		3	3	3	3	3	1	3	TBA
School gardens, parks, used for education		2	4	3	3	2	1	4	TBA
Universities study centres field bases		4	4	4	4	5	5	5	TBA
Other nature									
	Located fully on NATURA or other protected areas	1	1	4	4	4	3	4	TBA
	Located partially on NATURA or other protected areas	1	1	3	3	3	2	3	TBA
	Not located on NATURA or other protected areas	0	0	1	1	1	1	2	TBA

* TBA- to be agreed

In order to create the link between activities of provisioning of nature education and spatial units relevant for nature education service, a separate survey and queries were performed.

Each spatial unit relevant for nature education ecosystem service (which is visited by students) should in principle be categorized according to the type and valued according to the criteria (Table 36).

The assessment of the total value of ecosystem services supplied by a spatial unit requires spatially relevant data. Estimation of the nature education ecosystem services *in situ* requires data about the number of people receiving nature education and the location of the sites where it is received. In another hand the quality valuation of ecosystems belonging to a certain “value classes” is relevant for quantification of the benefits of nature education.

Methods for the monetary valuation, based on time use, expenditures and stated preference, also approaches for spatial distribution of the results are described in the following chapters.

The indicators for the quantification of the ecosystem education ecosystem service was decided to be “the number of hours spent on nature education”, “the number of hours spent in direct contact with the ecosystem”, “number of participants in nature programs”, “expenditures made for provisioning nature education”, “expenditures made for receiving nature education”.

The further refinement of the proposed approach is the subject of discussions.

3.3.9.4 Nature education as ecosystem service, data sources and survey

In Estonia, there are two kinds of providers of nature education. First, there are the owners (managers) of the nature education sites/nature trails and secondly there are nature education service providers who do not manage nature objects.

State Forest Management Centre is the largest and Environmental Board is the second largest provider of nature education service in Estonia, but there are also some smaller providers (schools, private enterprises). The datasets of State Forest Management Centre and Environmental Board were obtained by separate inquiries and analysed together with their experts.

For smaller service providers, three separate questionnaire types were designed depending on the activities and characteristics of the different companies and institutions (see ANNEX 10): whether these were nature/environmental education service providers or managers of some natural object(s) in addition. The destinations, visitors numbers, share of time in direct contact with ecosystem and the expenditures on delivering nature education programs were asked in the surveys. For the final step, the destinations were georeferenced.

The spatially informed database about the provisioning of nature education could be further refined and used in future work for valuing ecosystem service for other ecosystem types as well.

Data collected during the survey is shown in Table 41. Names of the used/ managed/ visited/ nature education trails and sites were collected in order to determine the coordinates of these trails and sites.

Table 41. Sources for the data about nature sites/objects

	Expenditures for the maintenance of nature education sites/tracks	Revenue from/expenditure for the provisioning of the nature education	Number of lessons given	Number of students	Time spent on nature studies directly in ecosystems	GIS data
Owners of the nature education sites/nature tracks:						
State forest Management Centre	Bookkeeping data	Admin data	Admin data	Admin data	Admin data	Received map layer
Environmental Board	Admin data	Admin data	Admin data	Admin data	Admin data	Manually allocated
Others	Survey data	Survey data	Survey data	Survey data	Survey data	Manually allocated
Service providers who do not manage nature objects	not relevant	Survey data /imputed/ extrapolated	Survey data /imputed/ extrapolated	Survey data	Survey data	Manually allocated

Some of the service providers conduct their nature education programs only in one certain nature trail or site, some of them use several, some visit sites all over Estonia and some deliver nature education programs where the client wishes. It is worth mentioning that these service providers quite often use the infrastructure provided by State Forest Management Centre. Hence, in order to avoid overlapping, we wanted to clarify the use of the infrastructure of State Forest Management Centre in the delivering of nature education programs by service providers.

The State Forest Management Centre (corporation, belonging to non-financial corporation sector) is the largest provider of nature education, managing four nature houses, 14 nature centres, nature school Sagadi Forest Centre, and Sagadi Forest Museum. Recreation and protection areas of State Forest Management Centre were visited in total 2.7 million times (51 000 nature education related visits) in 2018. The State Forest Management Centre used a total of six million € in 2018 to administer the visitor management infrastructure, preserve its state and organize activities promoting environmental awareness; 1.5 million of it was received as target financing from the European structural funds and was used to reconstruct the visitor management infrastructure of the protected areas. The share of nature education has been estimated by the State Forest Management Centre to be 10% from the total recreation related expenditures.

The analysis of the received data from nature education service providers was performed and the overview of the results is shown in Table 42.

Table 42. Distribution of providers of nature education service between market and non-market producers, number

	Market (S11, S14)	Non-market (S13, S15)	Other	Total
Owners of the nature education sites/nature tracks:		9	1	10
State forest Management Centre			1	1
Environmental Board		1		1
Others		8		8
Service providers who do not manage nature objects	8	27		35
	8	**36**	**1**	**45**

Current expenditures (mainly on educational programs and facilities), made by those who offer nature education service and own a nature area, where education programs are held were collected with a survey.

We also surveyed and explored the sales revenue from offering nature education service of the companies that supply nature education service and do not manage a nature object. Sales revenue was specifically asked because it was considered more accurately to reflect their environmental activity as they do not have current expenditures on managing nature objects. Subsidies and grants handed out by Center for Environmental Investments were also considered in order to get more information on the nature education provided by companies and ensure the quality of our results. Total current expenditures and revenue made by public and private service providers are shown in Table 43. Also, an attempt was made to get missing data from business reports if the survey was not filled.

Table 43 Providers of nature education service and expenditures made (thousand €)

	Market (S11, S14)	Non-market (S13, S15)	Other	Total
Owners of the nature education sites/nature tracks:		550	1 182	1 732
State forest Management Centre			1 182	1 182
Environmental Board		41		41
Others		508		508
Service providers without nature objects	9	226		236
	9	**776**	**1 182**	**1 968**

3.3.9.5 Nature education as ecosystem service: valuation

The theoretical overview of the relevant methods is described in chapter "Overview of the relevant studies and concepts for defining and valuation nature education service provided by ecosystems". In current chapter the following tested approaches are described:

1. expenditure transfer approach
2. expenditure based approach
3. travel cost approach

4. contingent valuation study: willingness to pay (WTP) for ecosystem services of Estonian grasslands

Future benefit (avoided cost) and time use based approach methods are discussed as well but the calculations were not performed.

The results from different applied methods were compared and the model Supply-Use table was compiled.

3.3.9.6 Expenditure transfer approach

Finding the monetary value of ecosystem education service through institutional education spending is based on the assumption that general education is a public service aimed to creating and improving the quantity and quality of human capital. The measure of the value of education is thus an increase in human capital through education, which, however, is difficult to express in monetary terms. Given that the vast majority of education is free of charge to consumers, it can be classified as a non-market public good, whose monetary equivalent can be obtained by using non-market valuation techniques. One such is the incurred expenditure method, which is an indirect method of economic valuation of non-market goods and values. According to this approach, the monetary value of education is considered proportional to the cost to society of providing education. The disadvantage of the method is that the value of education, calculated this way, is very likely to be lower than the value of human capital created by education. The strength of this method is that it is based on actual costs, which are well described in official statistics.

The method described above can also be used to evaluate the monetary value of both nature education and nature education as ecosystem service. Available data allows the total cost of institutional education to be attributed to the ecosystem through its share of hours in contact with the ecosystem. An important assumption for this approach is that the nature program trips should already be included in the official study programs so that time spent in direct contact with the ecosystem would make up one share of the total appointed curriculum of nature subjects in school. Our study does not fill this assumption very well as our data about nature trips was collected as an extracurricular or hobby school activities.

However, this caveat in mind, calculations were still made by applying the method to estimate the nature education service value of Estonian ecosystems by the total cost of hours of being in direct contact with the ecosystem. According to the expenditure transfer approach, the financial equivalent of nature education service value of Estonian ecosystems is approximately € 5.12 million per year. It was calculated as follows:

$$Nature\ education\ service\ value = a * b * c$$

where a - average time spent on nature studies directly in ecosystems (h);

b – number of students in nature education programs;

c – cost of one student hour, €. Calculated based on public expenditure on institutional education per year, number of students in institutional education (all levels considered) and average total number of lessons per student per year.

Parameter	Value
a - average time spent on nature studies directly in ecosystems (h);	5
b – number of students in nature education programs	116989
c – cost of one student hour (€). Calculated based on public expenditure on institutional education per year, number of students in institutional education (all levels considered) and average total number of lessons per student per year	8.75= =1300000000/(220000*675)

Given that the number of hours of nature education at the site has been determined, the total cost ascertained can be related to specific nature site based on visitor hours at the location. The value of education service for different ecosystem types present within the nature site can be divided by their proportion and also per hectare.

3.3.9.7 Expenditure based approach

Second expenditure based method for valuing nature education as an ecosystem service, considers also (as the method described in previous chapter) that expenditures made to provide nature education service reflect the value that society is ascribing to the service. The expenditures of those providing the nature education service are considered as the value of service. Assumption was made that the sales revenues cover at least the expenditures made.

We also considered SEEA EEA guidelines regarding the SNA approaches to valuing non-monetary transactions (p 5.4.3). UN SEEA EEA suggest that if market prices are not observable, valuation according to market price equivalents should provide an approximation to market prices. In such cases, market prices of the same or similar items when such prices exist will provide a good basis for applying the principle of market prices, provided the items are traded currently in sufficient numbers and in similar circumstances. This option is not relevant for educational service of the ecosystems. Where no sufficiently equivalent market exists and reliable surrogate prices cannot be observed, the SNA identifies a second-best procedure for use, namely, the cost of production approach[98], in which the value of the non-monetary transaction is deemed to be equal to the sum of the costs of producing the good or service, that is, the sum of intermediate consumption, compensation of employees, consumption of fixed capital (depreciation), other taxes (less subsidies) on production, and a net return on capital[99] (2008 SNA).

Discussions with the experts did reveal that considering the whole expenditure as ecosystem input is questionable, as it would represent the economic input to the production of the service (incidentally, although the ecosystem does ‘provide’ or supply the services). It has been also decided that it is important to distinguish the costs of the maintenance of nature education areas and providing facilities and the expenditures on service provision (specialized producers without the “real estate”). We had the access to the following expenditures data (shown in Table 44) which reflect in some way the value that society is putting on the educational experience. However, we have the opinion that this method does

[98] 2008 SNA, para 5.45
[99] 2008 SNA, para. 6.125

not allow to single out the part of the ecosystem input as there are just the expenses made by society and only a profit could be attributed to the ecosystem. Expenditure based approach has conceptual similarity with other “indirect i.e. transaction based” methods (like travel cost approach) where one could attribute the residual component as a share of the ecosystem.

Table 44. Expenditures on nature education provision by categories, 2018, million €

	Expenditures on nature education service, calculated on the basis of sales revenue and other income	Current expenditures on educational programs and facilities	Value of ecosystem nature education service
Non-market service providers (owners of nature objects)		0.55	0.55
Non-market service providers (not owning the nature objects)	0.23		0.23
State Forest Management Centre, market service provider but providing free nature education service		0.78	0.78
Other market service providers	0.02		0.02
Total	0.25	1.33	**1.58**

In order to calculate the total value of nature education service current expenditures, sales revenues and other incomes for supporting service providers were aggregated. Overlapping expenditure data was excluded as data taken into calculations was a) the current expenditures of service providers that own/manage nature sites, b) sales revenue and other income of service providers that use but do not own the sites. Total value of ecosystem nature education service in 2018 was ca 2 million € if one considers the expenditures of the providers of nature education service.

UN SEEA recommends decomposition of a market price into components and assumes that the costs of production include a normal return on capital as a common approach to value the production of education and health services. In case of market service-providers we can identify profit and theoretically attribute this to ecosystems then in case of non-market service providers this approach cannot be directly applied as non-market service providers do not receive profit from their activity. We assumed that the ecosystem contribution would be the same for market and non-market service providers and in order to determine contributions of ecosystem we decided to use the structure from market service providers. Average profit was calculated on the basis of available profit and sales revenue of companies who offer nature education service. Using available data, it was calculated that average profit was 17%. To apply this share to the value of the service calculated by expenditure method for non-market producers as well, then ecosystem contribution would be 0.3 million €.

The expenditures were linked to the georeferenced locations in our database. Based on georeferenced locations we mapped the specific expenditures with related location to get nature education service value map.

3.3.9.8 Time use based approach

In a discussion paper on recreation services compiled by David N. Barton and Carl Obst[100] time- use is described as a welfare value, based on monetary valuation approach. Time spent on an activity in a greenspace can be considered a good measurable indicator of the benefit generated by the service to the welfare of the recipient. However, the monetary value of time spent onsite on an activity is highly context specific and many assumptions need to be made to apply this method. One of the most significant being that it assumes that the alternative to the activity is work paid by the hour.

In our case, where the service is nature education and according to collected data, the recipients are mostly students in different levels of compulsory education. Therefore, it is not appropriate to apply this time use based method as the assumption of work paid by the hour does not stand considering that there is no legal alternative for time spent for studying for students. To try out this method, one might consider using other equivalent for expressing of students' time value in calculations, like present value of future salary.

It is also debatable how well the time spent on site (receiving education about the surrounding ecosystems) can describe the welfare derived from the activity at large, i.e. the real value of the contribution of ecosystems.

3.3.9.9 Travel cost approach

The travel cost method is usually used to value recreational uses of the environment. The model is commonly applied in benefit cost analysis and in natural resource damage assessments where recreation values play a role (Champ, et al 2003)[101]. The travel cost model is a demand based model for expressing a demand for recreational site or sites. Although the demand for a site can be modelled as an aggregate or market demand, the common practice is to estimate demand function on the level of the individual and to calculate site values by adding up individuals` values for the site (Myrick Freeman III, 2003)[102].

Although the travel cost based approach has been developed specifically to measure recreational value, our study attempts to use it to assess the value of the nature education service. This is possible because visiting ecosystems for educational purposes also involves travel costs.

It is important to note that in this work, the estimation of ecosystem education service based on travel costs is not a classic application of the travel cost method. Although actual travel costs are used to determine the monetary value of an ecosystem service, the approach used is not based on individual`s demand and the demand curve constructed on that basis.

According to the methodology, trip cost is the sum of expenses required to make a trip possible. Typical trip cost includes: travel cost, access fees, equipment cost and time cost (Champ, et al 2003).

[100] Barton, D.N., Obst, C. Discussion paper #10 Recreation services. SEEA Experimental Ecosystem Accounting: Revision 2020. Research papers on Individual Ecosystem Services. Version 7.1 17th December 2018
[101] Champ, P., Boyle, K., Brown, T (eds.). A Primer on Nonmarket Valuation. Kluwer Academic Publishers, 2003
[102] Freeman. A. M. III. The Measurement of Environmental and Resource values. Theory and Methods. 2nd ed. Washington, DC, 2003.

In order to provide nature education in contact with the ecosystem, students usually travel by bus. The difference from the classical application of the method lies in the fact that the trip is not paid by the students but by the tour organizer, which is either a school or a hobby school (usually method uses individual expenditures). Typically, there are no access fees and equipment costs for any such trips. It is also debatable to use time costs calculations for students because they have no income. Thus, travel expenses for students for educational purposes are the bus rental cost, typically paid by the tour organizer.

In Estonia, the cost of renting a bus suitable for student transportation depends on the duration of rental and not on the distance travelled. The total annual travel cost of providing institutional nature education in Estonia is € 2.024 million. It was calculated as follows:

$$Nature\ education\ service\ value = a * b$$

where a – average travel costs for one student (€);
b – number of students in nature education programs.

Parameter	Value
a – average travel costs for one student (€). Calculated based on average bus rental price (43,25 €/h), average rental duration (8 h), typical student group size (20)	17.3= =43.25*8/20
b – number of students in nature education programs	116989

A separate question is what proportion of the total travel costs should be attributed to the ecosystem. One possible approach is to attribute the profit margin of the transportation sector to entire travel costs and consider that as a share of the ecosystem.

According to Estonian statistics[103], the profit margin in the field of transporting and storage activities in supply and use tables is 3.548%. With this approach:

2.024 million € x 3.548% = 0.072 million € can be attributed to the ecosystems

Undoubtedly, the value of the ecosystem education service derived from the carrier's profits is modest and is likely to be underestimated. It was assumed that the profits generated by occasional bus services are higher than the group average in the statistics. The profits generated by occasional bus services were assumed to be around 15% by the expert opinion. With this approach:

2.024 million € x 15% = 0.304 million € can be attributed to the ecosystem.

In any case, the transfer of the monetary value found using travel cost based approach to the ecosystem needs further discussion.

[103] Statistics Estonia database, table RAA0043

The visitation rates were linked to the georeferenced locations in our database. To get nature education service value map we allocate travel costs to destination locations by their visitation rates.

3.3.9.10 Contingent valuation

A contingent valuation survey was conducted in 2019 to find out willingness to pay (WTP) for ecosystem services of Estonian grasslands. The CV questionnaire included a simulated market scenario, guidance questions, a WTP question and a sociometric section. An open end WTP question was: "I agree to pay … € per year for maintaining Estonian grasslands." The sample size was 414 respondents and the sociometric structure of the sample corresponded to the adult population in Estonia.

Based on the answers obtained, the demand curve was constructed which served as a basis for determining total WTP. Based on the quantified preference given to ecosystem services, total WTP can be divided between individual services (Table 45, WTP (thousand €)).

Table 45. WTP distributed between ecosystem services ordered by importance according to preferences

Ecosystem service	Average score in Likert scale	Total points received	%	WTP (thousand €)
Habitat conservation for biological species	3.72	1258	13.9	2610.7
Climate control	4.80	1622	10.8	2024.8
Photosynthesis (production of oxygen)	4.88	1651	10.6	1989.2
Ensuring landscape diversity	5.16	1740	10.1	1887.5
Maintaining soil fertility	5.18	1751	10.0	1875.6
Provision of genetic and medicinal resources	6.27	2118	8.3	1550.6
Enabling pollination and honey harvesting	6.31	2134	8.2	1539.0
Supply of agricultural produce	6.81	2302	7.6	1426.7
Flood protection	6.99	2364	7.4	1389.3
Enabling nature education	**7.64**	**2583**	**6.8**	**1271.5**
Provision of tourism and leisure services	8.10	2738	6.4	1199.5
TOTAL		22 261	100.0	18764.4

According to the Table 45, the service is in the penultimate position among all ecosystem services provided by Estonian grasslands. Considering respondents' preferences, 6.8 percent of the total aggregated WTP can be attributed to the service "enabling nature education".

Thus, the annual WTP for the ecosystem service "enabling nature education" provided by Estonian grasslands is 1.271 million €. According to the contingent valuation methodology, this can be considered as the annual monetary equivalent of the ecosystem value.

The WTP study and calculations were carried out only for Estonian grasslands. For the sake of comparability (as the other methods considered all ecosystems), we have made a rough estimation of the nature education service value regarding other services and describe this in the chapter "Nature education as ecosystem service: spatial dimension".

We can map the nature education service value for grasslands estimated by WTP method by the potential educational value of the nature site (Table 40).

1.1.1.2 Discussion of future benefit and avoided costs concepts in the context of nature education service

The aim of nature education is to grow the understanding of ecological systems and eventually to contribute to environmental improvements in the future. So, the service of nature education should in principle be valued also by avoidance cost method. However, the magnitude and cost of the future damages are currently not measurable.

Another theoretical concept what seems to be desirable is the contribution of nature education to the future benefit or income. Also, SEEA EEA TR touches upon it and gives the example from education economics (Chapter valuation 6. 22, 6.23). We know that according to CICES V5.1 definition[104] the main purpose of nature education is to "prevent the loss of the landscape characteristics and biodiversity of species" i.e. to avoid the degradation of the ecosystems. So, in principle capturing the future value of nature education in monetary terms seems to be relevant. Expert group has been discussing this issue and concluded that monetary expression of future ecological value related to nature education seems highly complicated, as even the concept of present value of education is not unanimously agreed.

We do not know if this approach (calculation of the future ecological value related to nature education) has been used for the valuation of education ecosystem service. In education economics the key questions is for example, how much the investments in education would bring back as a surplus in future. What could be the analogue for nature education?

Experts' opinion has been that counting our spending to understand the functioning of ecosystems better as a contribution of the ecosystem to society is somewhat circular akin to other spending on ecosystem maintenance and restoration. Separately they note that secondary benefits are not generally included in the valuations according to SNA (e.g. the future benefits from education are not generally recorded as the value of the education service in the National Accounts). This issue was also referred to relation to the future education benefits derived from improved health, in one of the SEEA EEA revision research papers on the topic of ecosystem services[105].

Experts thought that it might be worthy to discuss the replacement costs, but this would need more consideration.

UK National Statistical Office (ONS) is looking at using the value of the learning potential from degrees in ecology etc. It could be worth reviewing this approach in the future as well. Still the question remains what is the contribution of the ecosystem to the educational benefit here, if the purpose is studying the ecosystem.

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[104] Haines-Young ja Potschin (2018)

[105] Harris, R. 2019. SEEA Experimental Ecosystem Accounting: Revision 2020. Research paper on air filtration ecosystem services

3.3.9.11 Integration of nature education as ecosystem service in supply and use tables

In order to integrate the values of ecosystem services with national accounts, an attempt was made to add the results to extended supply-use tables using the same structure as is used in national accounts. Supply table includes sectors that offer services and goods. To integrate the table with ecosystem contributions it was necessary to add ecosystems as a supplying sector in addition to corporations, general government and NPISH (non-profit institutions serving households). Use table includes data of using services and goods. All the aggregate values of nature education service calculated by selected methods used during this study are shown in Table 46.

Table 46. Supply of nature education ecosystem service by used methods and suppliers, 2018 (million €)

	Service supply = Final use of the service by households	Total supply	
		Supply of economic sectors	Supply of ecosystems
Expenditure transfer approach	**5.12**	**Not relevant**	5.12
Expenditure based approach	**1.58**	1.31	0.27
Travel cost based approach	**2.02**	1.72	0.30
Contingent valuation method (covers only grasslands, ~6% Estonian ecosystems area)	**1.27**	**Not relevant**	1.27

For some of the methods (expenditure based and travel cost based approach) it was possible to distinguish contribution of the ecosystems separately but not for all. In the latter case the whole service value was attributed to ecosystems. The more detailed supply and use table for nature education service and the results of methods calculated during the study can be seen in Table 47 and ANNEX 11 following the logic of SEEA EEA TR table 8.1.

Table 47. The supply and use of nature education ecosystem service (million €), 2018

	Eco-systems	Corporations						General government			NPISH	Final consumption of households	Total
		A.02	H.49	L.68	M.74_75	P.85	R.93	O.84	P.85	R.90_91	S.94		
Expenditure transfer approach													
Supply													**5.12**
Ecosystem service – nature education	5.12												5.12
Use													**5.12**
Ecosystem service – nature education									5.12				5.12
Value added (supply-use)	**5.12**								**5.12**				
Expenditure based approach													
Supply													**1.58**
Ecosystem service – nature education	0.27												0.27
Nature education		0.65		0.00	0.00	0.00	0.01	0.03	0.07	0.41	0.13		1.31
Use													**1.58**
Ecosystem service – nature education		0.20		0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.01		0.27
Nature education									1.31				1.31
Value added (supply-use)	**0.27**	**0.45**		**0.00**	**0.00**	**0.00**	**0.01**	**0.03**	**0.06**	**0.37**	**0.12**		**1.31**
Travel cost based approach													
Supply													**2.02**
Ecosystem service – nature education	0.30												0.30
Nature education			1.72										1.72
Use													**2.02**
Ecosystem service – nature education			0.30										0.30
Nature education									1.72				1.72
Value added (supply-use)	**0.30**		**1.42**										**1.72**
Willingness to pay method													
Supply													**1.27**
Ecosystem service – nature education	1.27												1.27
Use													**1.27**
Ecosystem service – nature education												1.27	1.27
Value added (supply-use)	**1.27**												**1.27**
Sum of expenditure based methods													
Supply													**8.72**
Ecosystem service – nature	**8.72**												**8.72**
Use													**8.72**
Ecosystem service – nature education			1.72						7.00				**8.72**
Value added (supply-use)	**8.72**												**8.72**

First section “Expenditure transfer approach” includes values calculated with expenditure transfer approach where the whole supply is attributed to ecosystems because it was not possible to separate ecosystems and economic sectors. Ecosystem service user is government sector which then provides the service to students. The consumption of households is not included in the integrated table as it needs more data from various studies and it is not covered in SNA. In this method value added does not expand as the used data is already included in SNA. In principal integrating ecosystem as a separate supplier demands to lessen value added of general government in order to avoid double counting.

Second part “Expenditure based approach” includes values calculated with expenditure based method. Nature education service providers are ecosystems and various economic sectors that belong to different NACE activities. In use part of table, ecosystem contribution (0.27) is divided between all economic activities that use ecosystem service to provide their services (it was assumed that most of them use 10% and the largest supplier balanced the supply and use). It is because ecosystem contribution does not expand value added but divides already made and accounted value added (1.3) between economic industries (1.03) and ecosystem (0.27). Industries use ecosystem educational service as an input to supply nature education service. As the supply and use of the service is already included in SNA (economic industries supply the service) then the value added cannot be larger. This section shows the part of industries value added which comes from ecosystems (0.27).

Third section "Travel cost based approach" includes values calculated using travel cost based approach where suppliers are ecosystems and transport sector. Users are transport sector that use ecosystem service to provide their service and households. The logic in this section is the same as was in expenditure based method – supply (2.03) and use (2.03) are larger than value added (1.73) because already accounted value added is distributed between ecosystem and transport activity. It is seen that a part of transport sectors value added actually comes from ecosystems (0.30).

Fourth part "Willingness to pay method" includes values calculated with willingness to pay method where suppliers are ecosystems and users are households. In this section also total value added expands (1.27) because the service value calculated (supply 1.27, use 1.27) with willingness to pay method is not accounted in SNA and is an addition to already included values. Nature education as ecosystem service, analysis of the applied valuation methods and a comparison.

Fifth part of the table includes total of three expenditure based methods. The supplier is the ecosystem and users are transport activity and general government.

3.3.9.12 Comparison of the methods for the valuation of nature education ecosystem service

The criteria for the evaluation were selected to highlight various methodological aspects and also allow to value the consistency of methods with the recommendations of UN SEEA EEA. Criteria are partly based on those, described and applied in a "Valuation method selection criteria – a proposal. Working Paper for discussion at Forum of Experts on SEEA Experimental Ecosystem Accounting 2018 11 June 2018" by David Barton[106]. In addition the developments of these criteria in discussion paper 5.1 "Defining exchange and welfare values, articulating institutional arrangements and establishing the valuation context for ecosystem accounting" prepared by the experts as part of the work on the SEEA EEA Revision coordinated by the United Nations Statistics Division, was considered.

Table 48 below provides an insight for the evaluation of the used methods.

[106] Barton, D.N., 2018. Valuation method selection criteria – a proposal. Working Paper for discussion at Forum of Experts on SEEA Experimental Ecosystem Accounting 2018 11 June 2018. https://seea.un.org/sites/seea.un.org/files/documents/Forum_2018/seea_eea_expert_forum_2018_-_discussion_paper_on_valuation_paper_2.pdf

Table 48 Comparison of the methods for valuation of nature education ecosystem service, correspondence to criteria

Method/criteria	Expenditure transfer approach	Expenditure based approach	Contingent valuation	Travel cost approach	Time use based approach
Description	Education costs are attributed to the ecosystems (on the bases of hourly lesson prices)	Expenditures to provide nature education are calculated and ecosystems contribution is found	Willingness to pay for education service	Students travel costs are attributed to the ecosystem	Value of the time spent in contact with ecosystem studying is attributed to the ecosystem
Conceptual consistency	Low, two-step assumption	High, based on real expenditures	High, classical application	Low, non-classical application	Low
Production boundary					
How well is it reflected in SNA, 5.1. table 1.1 yes/no	yes	Yes	no	Yes	No
How well is it reflected in SNA, channels according to Doc 5.1. figure 1.1	2	1,2	4	3	4
Double counting in sense of service value (Does this identification reduce the likelihood of double counting?)	Probable double counting of educational public expenditures	Not relevant	Not relevant	Not relevant	Not relevant
Routine production	no	No	no	No	No
Need for extra study	yes	Yes	yes	Yes	Yes
Institutional compatibility (are the assumptions used the same as for institutions governing ecosystem service use)	no	Yes	no	Maybe	No
Is the method vulnerable to zero or low monetary values? (relative to level of biophysical flows), Significance	Yes, as it depends on government funding	Yes, as it depends on government funding	Yes, as WTP depends on welfare	Yes	Yes, as students do not have salary
Robustness (Is the valuation method complex, subject to a large number of data transformations and modelling assumptions? (methods with few data transformation steps and assumptions are more robust)	Low, as there is a two level assumption	High-medium, quite straightforward	High, if applied properly	Medium-low, as several assumptions involved	N/A
Accuracy	Depends on the response rate	Depends on the response rate	Depends on the sample size and quality	Depends on the response rate	No, students time value is not known and it is indirectly linked to ecosystems
Technical complexity	Yes. GIS-analysis	Yes. GIS-analysis	Yes. GIS-analysis Special software	Yes. GIS-analysis	N/A
Information cost	Yes, depends how often additional study is carried out	Yes, depends how often additional study is carried out	yes	Yes, depends how often additional study is carried out	Yes, depends how often additional study is carried out
Other policy applications	No	No	No	No	No
Computational demand (table 4.1)	High, when to consider GIS-analysis.	High, when to consider GIS-analysis.	High, econometric analysis; GIS-analysis	High, when to consider GIS-analysis.	N/A
Challenges	Can public expenditures per education unit be used to calculate the education service value of ecosystems?	Is it right to attribute the profit of nature education service to ecosystems? Or count all expenditures made as ecosystem service?	Linking stated preferences to SNA.	Which part of the transportation costs can be attributed to ecosystems, profit?	What can be used as equivalent for expressing students' time value in calculations?

In the classification of ecosystem services, education service is regarded as cultural service (CICES V5.1)[107]. This determines the nature of education services and the choice of methods for economic evaluation of ecosystem education service.

An educational service is one of the non-market services that does not produce a market product and therefore the monetary value of which should in principal be assessed by the revealed preferences or stated preferences associated with the service.

Unlike recreational ecosystem service similar to educational ecosystem service, the distinctive feature of educational services is that the financial costs of providing an educational service are relatively well defined and can be expressed as a specific amount of money. This is valid both to public education expenditure and to investments into nature education infrastructure at sites, where the learning process takes place in direct contact with ecosystems. This makes it possible to use the expenditure transfer approach although part of the expenditure on education is attributable to the ecosystem. This method

[107] Haines-Young, R. and M.B. Potschin (2018):Common International Classification ofEcosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Available from www.cices.eu

requires data about expenditures made for education and defining the role of the ecosystem in providing nature education. The role of the ecosystem in providing nature education can be evaluated in several ways. In current study, in some cases, the ecosystem component is taken as a proportion to the number of lessons that takes place in direct contact with the ecosystem.

This approach has been applied to the expenditure transfer method, where public sector expenditures on lessons are attributed to the ecosystem according to the actual lessons taking place in contact with the ecosystem. The advantage of the method is that the educational value of the ecosystem is based on the actual expenditure on education and the number of student hours actually spent in the ecosystem. The disadvantage of the method is that the concept is speculative and based on the assumption that the educational value of the ecosystem is expressed through contact hours.

The second method, the expenditure based approach, is based on the cost of actual expenditures made, to provide nature education in the ecosystem. Its strengths are that it is based on actual expenditures, there is a direct link between expenditure and nature education, and the possibility of linking expenditure to specific locations. The disadvantage is that this approach does not take into account other nature education expenditures (such as transport costs, labour costs) and should be combined with other methods to find out the total value of ecosystem as a provider of nature education (as there are other costs to be considered such as household expenditures). The advantage of both cost-based methods from the accounting point of view is that the value attributed to ecosystems is included in the SNA and the application of the methods does not require extensive specific research.

The travel cost based approach, which has also been applied in this work to find the financial equivalent of the educational value of the ecosystem, is also based on actual expenditures. This method is widely used in the economic valuation of non-market values of nature. Classically implemented, the method is based on individuals' travel expenses, which are used to construct a demand curve for ecosystem service and to calculate aggregate demand. In our case there is a deviation from theory in evaluating an ecosystem education service using the travel costs, as students who visit ecosystems for educational purposes do not make individual expenditures, but the trips are financed by the school or sponsor. It is also a questionable of what proportion of travel costs can be attributed to the educational value of the ecosystem. For example, it is not clear if it is relevant to apply the concept that the educational value of the ecosystem equals to the profit of the carrier company, as carriers may be subsidized in Estonia. This method has the advantage of taking account of the actual costs and the possibility to allocate costs to specific locations.

The nature education as ecosystem service values found using three methods which all belong to the group of revealed preferences, mostly do not overlap. When double counting can be eliminated, then in principle consideration may be given to sum them up in order to determine the total value of the nature education service. While summing up the values received by different methods one still has to consider that two expenditure methods may overlap regarding some expenditures made by general government. Also overlapping is difficult to detect as the calculation logic of methods differ.

The fourth method used in this study was contingent valuation method (CVM), which is a stated preference method and is very widely used in estimating the non-market values of nature. The strength of the method is that it measures the welfare that ecosystem services provide to individuals. The disadvantage of the method is the poor relation to SNA and real turnover, which currently makes the integration of the values found by this method difficult with environmental accounting. The implementation of the method also requires considerable costs. However, CVM is the only method that measures the impact of the educational value of an ecosystem on well-being, so it measures value precisely according to the concept of welfare economics, whereby everything that positively affects well-being has value.

Another theoretical option for estimating the nature education service value of an ecosystem, is based on the price of time, this approach is not well applicable here, since pricing a student's time is questionable unlike the wage earners.

Methodological work on the valuation of nature education ecosystem service has raised some questions which were discussed in the London Group of Environmental Accounting[108], methodological seminar held in Tallinn in November 27th -28th and were also discussed with the experts after the meeting[109]. Table 49 providers the summary of the issues and opinions discussed with the revisers of UN SEEA EEA[110].

Table 49. Nature education service methodological questions raised to the London Group and answers

Questions posed	Opinions
1. Is the conceptual framework (ecosystem plays the role of the "enabler" and society plays the role of the "shaper") helpful when defining cultural ecosystem services, especially nature education service?	It was discussed that in general terms Fish et al model seems acceptable. Both aspects (ecosystem plays the role of the "enabler" and society plays the role of the "shaper") are needed to define the presence and extent of a service. The model was assumed to be consistent with the approach to ecosystem services that has been taken in the SEEA EEA. It was noted that the model does not answer the questions how to quantify the enabling and shaping influences of ecosystems and society on services as such.
2. Can the number of visits and the number of contact hours be considered good indicators for measuring nature education service value?	Several of the experts considered that the number of the visits is a good measure to quantify the flow of nature education services. It was noted that this yet does not help to measure of their monetary value.
3. How important is it to determine the area which supplies nature education? Are there acceptable criteria for assessing spatial units relevant for nature education service available? How to include the educational potential in assessing nature education service flow?	This questions was discussed in several fora. The importance of the supplying areas was not considered important for macro assessments of the total flows of nature education. However, the determining of the location and area of the supplying ecosystem was considered important if to answer a question about the relative importance of a particular ecosystem and ecosystem type
4. What is the extent of the service supplying site (e.g polygon radius based on trail length)?	Further research in this area was suggested. A David Barton study on the relevance of specific ecosystem features to support recreation activity but not much can be found for framing nature education services.
5. What indicators of condition would be relevant to the assessing the continuing capacity of the ecosystem to supply nature education services?	It was ensured that the features that underpin the supply of the service are important. For example the indicators that would reflect the ecological integrity where considered to be relevant in current study and taken into consideration

108 25th Meeting of the London Group on Environmental Accounting 7-10 October 2019, Melbourne. https://seea.un.org/sites/seea.un.org/files/lg_article_nature_education_as_ecosystem_service_estonia_03_oct.pdf.

109 Methodological discussions on a seminar November 27-28, 2019 (Annex 2) with Sjoerd Schenau and Rocky Harris.

110 on the basis of the personal communication with Carl Obst, leader of UN SEEA EEA revisioning team

6.	Is the assumption valid that the value of education is at least as big as expenditures made to obtain it?	The assumption was discussed and it was pointed out that expenditure value only the certain contribution of the ecosystem. But the idea of basing the valuations on expenditures in some way was welcomed. The main question to handle was focused on issues on which expenditures to include. It was cautioned that a reverse argument might be made that the value of the nature education ecosystem services cannot be larger than the expenditures made to obtain it – i.e. expenditures were supposed to create an upper bound. The relative contribution of the ecosystem to the benefit would then be the question look the answer for.
7.	How to find the share of the contribution of ecosystem from the total service value found with the non-market valuation methods?	Defining the share of the contribution of ecosystem in total service value found with the non-market valuation methods was still considered to be an open question that needs an answer. Pattern of expenditures to obtain the benefits was proposed to deliver a demand curve that would be a proxy for the demand for the ecosystem service. The challenge of the interpretation of the supply of the ecosystems services was noted in that respect.
8.	Should the consumption of nature education service in the use table be attributed to households or rather to the companies that supply the educational service to households? Does the distinction between users and beneficiaries in the supply and use table depend on the methodology that is used to value the service?	Discussions UN SEEA revision team experts have clarified that there is no final position as yet. Both treatments can be consistent with national accounting principles and it was noted that a similar question arises for recreation services. The clearest way forward seemed to record the flow as an input to the companies.

3.3.9.12.1 Selection among the test approaches

Despite the fact that the UN SEEA EEA is still in revision and there is no clear understanding and guidelines on several concepts, in our current work we had to choose one of the service values or to derive a sum of the components as we try also to aggregate values for different ecosystem services (provisioning, regulative and cultural) on ecosystems type level (grasslands in the current circumstances).

For nature education as ecosystem service valuation, the challenge was that we used distinctive expenditure based approaches as different ways to approximate the value of the nature education service:

1. Value of education service calculated with expenditure transfer approach is considered proportional to the cost that society spends to provide education and are attributed to the ecosystems on the bases of hourly lesson prices (we used the number of the hours spent).

2. Second expenditure approach is based on survey results: expenditures and investments made for maintaining of nature sites and also sales revenue of companies which supply the service.

3. Third approach includes only travel costs of students to reach the learning area.

Different expenditures were not clearly measuring different components of the nature education service. However, some of the different components of the nature education service could be probably valued separately and then summed[111]. Summation of all three separate values was considered appropriate if only the double counting would be removed.

We think that first (1) and the second (2) approach may overlap to certain extent because expenditures of government units that supply the nature education service are integrated in both approaches. The disadvantage of the first approach is that it is not possible to define the residual that could be considered as ecosystem contribution and the whole value was attributed to ecosystems (contrary to second approach).

The service value calculated by first (1) method is much higher than that of the second (2) approach. This rather big difference in expenditure figures is explained by just the partial coverage of all expenditure components in case of survey data (second approach, 2). Not all nature service suppliers and government spending's on nature education are covered.

Methodologies were discussed with project experts and stakeholders and generally agreed with. Statistics Estonia had to choose a method for assembling the results of different ecosystem services. In one hand resource rent to private sector (non-transport) service providers were considered to be surely valid for the accounts, additional (travel) costs of visits could be taken as indicative of WTP for extra benefit from the 'normal lessons as well. It was suggested by Dutch experts to add the values calculated with the expenditure transfer approach, expenditure based approach and travel cost approach as these describe different aspects of the service and different expenditures/costs are used as input data. After the discussion on a seminar the latter was chosen: first (1) second (2) and the third (3,) approach were summed (as these represent distinctive kinds of expenditures) for aggregation purposes.

3.3.9.13 *Spatial distribution of nature education ecosystem service*

For country level macroeconomic assessments of the total flow of nature education ecosystem service, the spatial dimension e.g. defining the area supplying nature education service are not important. On other hand, if to analyse the relative importance of a specific ecosystems or ecosystem types and if nature education services is considered to be one of the important services, then the spatial dimension e. g. the location, quality and other parameters of the area of supplying ecosystem services are important.

In current work, we have estimated the total, i.e. across ecosystem types, service value and later distinguished the contribution of different ecosystems to the annual nature education service values.

The sites which provide the nature education were mapped and the map of the education service providers was formed. Spatial data was obtained mainly from two different sources: 1) from State Forest Management Centre which provided data for nature education sites which are maintained by them, 2) The database of other nature education service providers which was separately compiled by Statistics Estonia as a result of the study carried out during current grant (see ANNEX 10 for questionnaires).

Information available from State Forest Management Centre regional level on nature education visitation rates of specific programmes in nature education centres was linked to the nature trails and sites according to the information on study trails available in the SFMC webpage and distributing the

[111] Outcomes are presented in the supply and use table prototype (page:…) following the logic (SEEA EEA TR table 8.1., page 132) compiled using the data and the results of methods of nature education service.

visitations equally between the trails that contribute in the provisioning of the nature education ecosystem service.

3.3.9.13.1 Digitization of objects for ecosystem educational services

On the basis of collected data about other nature education service providers, the nature education sites (nature education centres of Environmental Board, results of the study of other nature education centres, hiking routes with educational components, school gardens, parks used for education, universities study centres and field bases) were digitalized, the map layer of nature tracks and sites was formed and after this the polygons contributing to the service provision were formed.

Digitization of objects for nature education service consisted of two subtasks:

a) Creating buffer zones for nature education sites (SFMC)

b) Digitization of nature education areas (non-SFMC).

Digitization of the objects which related to nature education was a rather time consuming as there were no clear criteria for digitization.

Regarding the nature education objects of State Forest Management Centre the correctness of the map layers (points, lines, regions) was checked. Buffer areas with a radii of 500m were drawn around the objects to determine the contributing ecosystems.

Regarding the other nature education service providers, the objects, (maintained by other state-owned or private companies, NGOs, self-employers etc.) were digitized and mapped. Source information was based on the responses to a questionnaire prepared by Statistics Estonia which was sent to 415 potential service providers. Questionnaire consisted service providers (legal entities) registry code, name, education site names and locations, costs incurred, and some information in free form comments. According to the criteria developed, the service providers for whom it was unclear where exact nature education was provided (location of the site), we were unable to georeferenced that data, hence this information was not used. Those service providers, who provided nature education only indoors were also excluded. In all other cases, the trails were drawn or the area was delineated according to information available on the Internet, Estonian Nature Information System, Land Cadastre etc. A total of 218 service providers' objects were digitized. The objects were then buffered with 500m buffer.

Most of the objects had to be digitized from single point information. In some cases, the object was identifiable as either a land register / cadastral unit / object of the Estonian Nature Information System or recreational object of the State Forest Management Centre. In most cases we created virtual trails to represent nature objects or the a pictures (.jpg or .png, not GIS-format) of the trails resulting from google search had to be digitized.

The general criteria for the creation of the polygons for nature education objects were as follows: the area surrounding the nature education objects with 500 metres to all directions (500m buffers) was considered. We overlaid nature education objects (with 500m buffers) with ecosystems unit map and accounted with all the ecosystems that intersected with nature education objects (with 500m buffers).

3.3.9.13.2 Value of nature education ecosystem service by grassland types.

By overlaying the ecosystem unit map and mapped nature education sites, we obtained the share (in area units) of each ecosystem type in the educational areas. We divided total education service value between ecosystem types according to the share of each ecosystem type area in total ecosystem type area in nature education provisioning area.

In order to consider the different visitation rates of various sites providing nature education, the nature education object data was supplemented with the data on visitation rates. For the nature education service providers, collected visitations data were linked directly to the respective nature education provisioning area. For the State forest management Centre, the visitation rates of nature education sites were estimated based on belonging to the nature education programme area (mostly equals the visitation centres).

The value of provided nature education ecosystem service by the types of grasslands was calculated in two ways: not weighted by visitation rates (ecosystem area was considered) and as by weighted by visitation rates.

In order to find annual educational service values related specifically to grasslands, the grasslands share in nature education provisioning area was used. The values of the ecosystem service of providing educational services regarding grasslands are shown in Table 50 and visualized in Figure 13. The contribution of the grasslands to the nature educational ecosystem service is 917.1 thousand €, if to consider just the contribution of the area to the service value. If we additionally consider the visitation rates of the various nature education sites, the lower value could be allocated to the grassland nature education sites which is 750 thousand €. Visitations rates weighted valuation method was preferred as it was considered more precise. Semi-natural grasslands contribute the biggest share, despite their lower share in territory. Semi-natural grassland contribute 2/3 of the service value if we consider the area visited for nature education purposes. If we also consider visitation rates, other non-specified semi-natural grasslands form around half of the grasslands contribution to ecosystem service value.

Nordic alvar and Precambrian calcareous flatrocks and Boreal Baltic coastal meadows provide 25% of the ecosystem nature education service if to consider just the contribution by area. If to consider also the visitation rates in addition, these contribute about 10% of the nature education ecosystem service value.

Table 50. Value of provided nature education ecosystem service by grassland types, euros, 2018.

Grassland type	Ecosystem service value based on area	Ecosystem service value based on visitation numbers
Grasslands total	917 140	753 374
Semi-natural grassland	**608 103**	**631 821**
Semi-natural grassland according to the NATURA classification	**420 833**	**283 485**
Boreal baltic coastal meadows	100 998	27 205
Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	10 436	2 424
European dry heaths	2 752	1 579
Juniperus communis formations on heaths or calcareous grasslands	20 104	10 416
Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	24 309	14 041
Fennoscandian lowland species-rich dry to mesic grasslands	18 650	30 355
Nordic alvar and precambrian calcareous flatrocks	103 544	48 161

Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	5 223	2 661
Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	16 261	16 857
Northern boreal alluvial meadows	61 663	75 300
Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	32 469	31 435
Fennoscandian wooded meadows	16 619	9 251
Fennoscandian wooded pastures	7 806	13 799
Other semi-natural grassland	187 270	348 336
Permanent grassland	306 270	120 829
Environmental sensitive permanent grassland	2 767	724

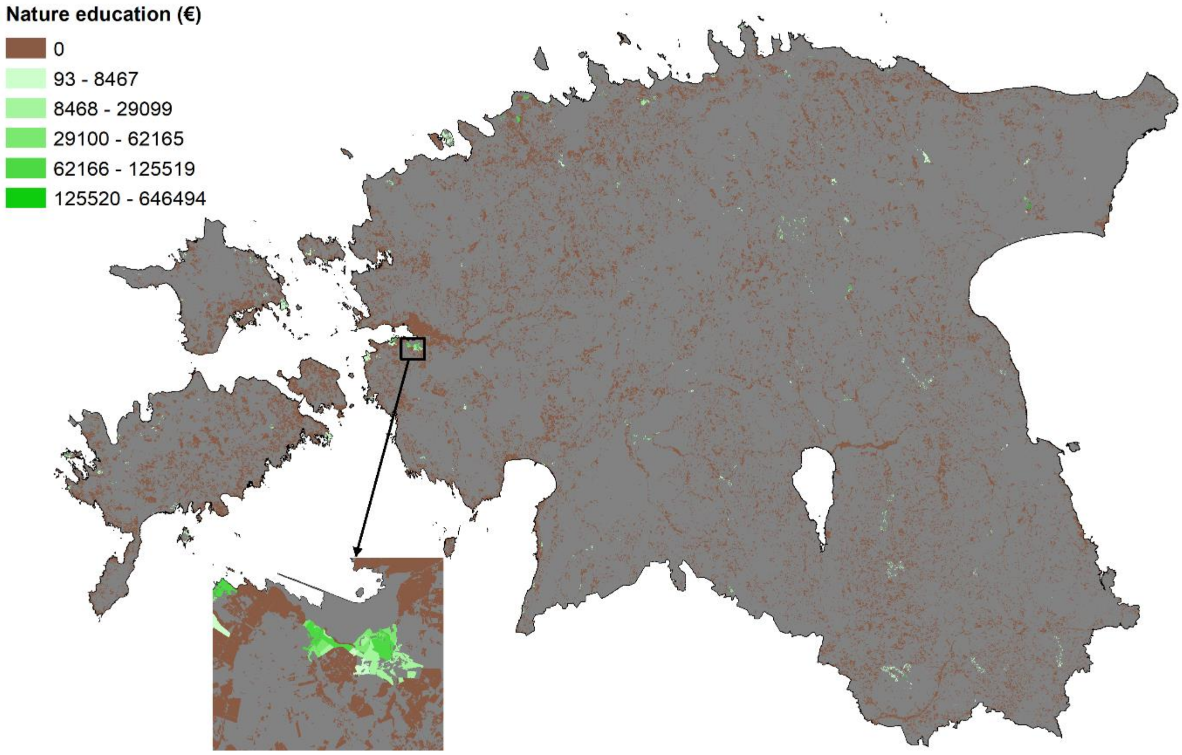

Figure 13. The ecosystem service provisioning areas and values of nature education of Estonian grasslands. The areas coloured in the scale from brown to green represent grasslands according to the value they supply the service that was calculated using cost based approaches and values were distributed by visitation rates. The values shown correspond to the total value of ecosystem service per grassland type. Dark grey areas are other ecosystem types that were not analysed in the current work.

In general, both of these grassland types are known by remarkable biodiversity and also educational value[112]. However the condition (quality) aspects of nature education providing ecosystems were not considered when the spatial allocation of the service value was performed. Currently there is no agreed criteria yet to be applied. In current grant the effort was made to develop the criteria relevant to specific ecosystem features to support nature education activity. The quality parameters of the site and the correspondence to the criteria which were developed (shown in Table 40), were not considered in

[112] Nature Conservation Development Plan until 2020. Ministry of the Environment Tallinn 2012. https://www.cbd.int/doc/world/ee/ee-nbsap-v2-en.pdf

calculations, as it takes time and effort to obtain relevant spatial information for each nature education provisioning area and integrate this in our spatially informed database. Educational value of the nature education provisioning sites, the learning Infra-structure, rarity, representativeness, diversity, provisioning of the scientific knowledge and ability to reflect ecosystem processes, were considered to be important in sense of the service flow specific features but to obtain this all this, would need a wider revision of the available information. After that, it would be possible to distinguish the areas used for nature education according to the quality classes. Data of Natura 2000 protected areas network and data of protected areas which are outside of Natura 2000 network could be added in valuation calculations in first order.

Based on the suggestions of the project experts, all partially intersected ecosystems were included to the nature education contributing ecosystem area in order to account the areas/ecosystems that support nature education service at the site.

3.3.9.14 Conclusion

In general, per unit ecosystem area, ecosystem service value depends both on socioeconomic variables (see chapter on scope 3.3.9.2.) and on nature education quality values (Table 40) that ecosystems can provide. The nature education ecosystem service values relevant to socioeconomic indicators have to be adjusted with the spatial context to specific educational capacity, potential and condition factors. In discussion paper 5.1: "Defining exchange and welfare values, articulating institutional arrangements and establishing the valuation context for ecosystem accounting" (prepared by the experts as part of the work on the SEEA EEA Revision coordinated by the United Nations Statistics Division), the proposed concept that exchange values (based on actual costs) of management constitute to a lower bound for welfare values, could comprise also a solution how to address various qualities of nature education. The developed table (Table 5 "Categorization of nature education provisioning sites by nature education value") could be used as a guide for spatial distribution of nature education service values. In the future, the applicability of the developed matrix for deriving of the potential capacity will be analysed.

The aspects of the qualities (values) of nature education service and derived various estimates of nature education service value should be addressed in dialogue with wider ecosystem accounting community, ELME team: ecosystem services mapping and bio-physical supply currently, MAES application team, IPBES experts and also other users.

We agree with one of the key findings outlined in discussion paper 5.1: "Defining exchange and welfare values, articulating institutional arrangements and establishing the valuation context for ecosystem accounting"(prepared by the experts as part of the work on the SEEA EEA Revision coordinated by the United Nations Statistics Division) that given the importance of value transfer for accounting, specific guidelines on spatial scaling of monetary valuation estimates from primary study sites to accounting areas will be needed. We have taken one step in that direction.

The suggestions received from the London group of environmental accounting where the work was presented and by the member UN SEEA EEA revision team[113] were to contribute further to the development of the methods for defining nature education ecosystem service.

3.3.10 Other ecosystem services

3.3.10.1 Ecosystem habitat provisioning service

Ecosystem habitat provisioning service was one of the services that was initially chosen as a candidate service for valuation. The concept of ecosystem habitat provisioning service has been preliminary analysed by Estonian national experts and the service handling in accounts (intermediate service or final service) was also presented and discussed on a seminars with international experts. Three approaches to value the service were discussed: methods which use individuals real or hypothetical spending, the methods based on habitat maintenance costs and loss-of-income from alternative use.

Before choosing methods for evaluating an ecosystem habitat provisioning service, the concept of the service had to be clarified and the question had to be answered: how could the habitat provisioning service be identified and analysed and whose welfare does it enhance? The concept of value in environmental economics is closely linked to the definition of value known from welfare economics: all environmental goods and services that have a positive impact on the well-being of individuals have value. The concept of monetary valuation of ecosystem service values as environmental goods and relevant methods are also based on this concept (see e.g. Garrold, G. and Willis K.G., 1999)[114]. It is clear that ecosystem habitat provisioning service does not mean human habitat, but habitat for biological species that are living in the ecosystems. Because of this, many experts have opinion that habitat provisioning service is an intermediate service and do not value it in monetary terms. This viewpoint can be (at least partially) agreed by the authors. In this case, the ecosystem habitat service, as an intermediate service reveals itself through the value of biological species (species diversity), which is usually considered as a value of biodiversity. There are many examples of monetary equivalent of the value of biodiversity (e.g. Kontoleon, A. et.al Eds., 2007[115] ; Pearce, D. and Moran, D [116]) as well as the value of individual species[117]. One way to assess of the monetary value of biological species is the use of the stated preference methods (e.g. contingent valuation) which is particularly often used in monetary valuation of non-market environmental goods, occupying often a large volume of a leading journal in its field "Ecological Economics" (e.g. Tokunaga, K., et al. 2020)[118] .

Assuming that the existence of species is mainly possible due to suitable habitats, part of the monetary value allocated to biodiversity (or species) should be attributed to habitats. As habitats are a prerequisite for the existence of species, the value of habitats is included in the value of biodiversity However, if one

[113] -personal communication with Carl Obst
[114] Gui Garrold, Kenneth G. Willis. Economic Valuation of the Environment: Methods and Case Studies. Edward Elgar Pb, 1999, 384p.
[115] Kontoleon, A., Pascual, U., and Swanson, T. Biodiversity Economics. Cambridge University Press, 2007, 664 p.
[116] Pearce, D., and Moran, D. The Economic Value of Biodiversity. IUCN 2009, 172 p.
[117] Carson, R.T. Contingent Valuation. A Comprehensive Bibliography and History, Edward Elgar Pb.,2011, 454 p.
[118] Tokunaga, K, Sugino,H, Nomura H, Michida, Y. Norms and the willingness to pay for coastal ecosystem restoration: A case of the Tokyo Bay intertidal flats. Ecological Economics 169 (2020) 106423. www.elsevier.com/locate/ecolecon

attempts to value of a habitat provisioning service independently from biodiversity, no revealed nor stated preferences of individuals based approach is appropriate, because people are not (direct) users of the habitat service and there is no link between the monetary value of the service and the costs made by individuals. In this respect, the habitat service differs from the recreational service, although both can be provided by the same ecosystem.

Excluding the methods which use individuals real or hypothetical spending, the methods based on habitat maintenance costs and loss-of-income from alternative use still remain. It is relatively easy to estimate the habitats maintaining cost in protected areas, which main task is protecting habitats from economic activity and especially for the exclusive resource consumption, e.g. clear-cutting of forests.

According to the cost-based method, habitat maintenance costs could be attributed to the value of the habitat(s) and the value of the habitat(s) service is considered to be the financial value of the expenditure made. It should be emphasized that this method is only applicable to habitats for which specific and clearly documented financial costs are incurred regarding conservation.

The loss-of-income method is based on the fact that a special regime is established for protected areas, limiting the common (profit-making) economic activity. Restrictions on economic activity inside protected areas lead to a loss of income that would be available in a similar area outside the protected area. This monetary value of the foregone income (or non-received income) could be attributed to the habitat as a monetary equivalent of the ecosystem habitat service.

Both the “expenditure” and the “loss of income” methods are practically applicable for the monetary evaluation of habitat service of protected ecosystems but their practical application depends on whether the ecosystem habitat provisioning service is treated as final service, which should be evaluated separately from the biodiversity.

Current concept of the ecosystem accounting does not allow clear valuation and allocation of biodiversity service. The value of biodiversity, which have been handled as a value of habitat provision is considered by several experts to be an “intermediate service” but it does not need to be considered as such. It was discussed that biodiversity service could be expressed also as cultural psychosocial service. According to the opinion of some project experts, the value of biodiversity is by its very nature a final ecosystem service that directly contributes to the human well-being. After all, high biodiversity is the main reason why semi-natural grasslands are often protected and paid for (preserved). For example preserving the biodiversity (in this work, the habitat service) is the most important reasons for subsidizing semi-natural grasslands maintenance and management. Habitat service value is a prerequisite for but is not identical with, the value of biodiversity. How to assess the value of biodiversity is a separate issue, but according to the opinion of some experts it is clear, that the exclusion of this service value reduces the value of semi-natural habitats as a provider of ecosystem services. Despite the fact that subsidies are paid for the maintenance of the habitats, the paid subsidies cannot be allocated as the value for the ecosystem services due to the above mentioned conceptual issues. Other experts are of the opinion that biodiversity is not the ecosystem service but the habitat provision is and that the biodiversity is merely an indicator.

3.3.10.2 Other ecosystem services discussed

In addition to the ecosystem services that were included in the final selection (chapter 3.2.1.), some other ecosystem services were discussed but these were not chosen for valuation due to different reasons (see ANNEX 9).

Food provisioning (agricultural, livestock) was discussed, but was considered as not relevant, when assessing grassland ecosystem services. We did not include food from agricultural sources (milk, meat etc.) as a ecosystem service because the livestock production is already part of the economy, hence it is not an ecosystems service but rather the benefit. As benefit is not a service, it would not be consistent with SEEA and SNA to add this service in the ecosystem services account. Provisioning of game was included in the monetary valuation but the category "food from wilderness" includes also edible wild plants, berries, and mushrooms but because grasslands are not great contributors in provisioning these, it was currently left out from the assessment.

Other ecosystem services which were also considered important for monetarily valuation but due to availability of data and time restrictions were not considered in current study:

- Protection from flooding,
- Maintenance of soil fertility,
- Natural pest control,
- Aesthetic appreciation and inspiration for culture, art and design,
- Spiritual experience and sense of place.

3.4 Use of contingent valuation methods for the valuation of ecosystem services: Willingness to pay (WTP) for ecosystem services of Estonian grasslands: a contingent valuation study

A contingent valuation survey was conducted in 2019 by Tallinn Technical University in association with current work. The focus was on finding out the willingness to pay (WTP) for ecosystem services of Estonian grasslands. The CV questionnaire included a simulated market scenario, guidance questions, a WTP question and a sociometric section. An open end WTP question was: "I agree to pay … € per year for maintaining Estonian grasslands." The sample size was 414 respondents and the sociometric structure of the sample corresponded to the adult population of Estonia.

Based on the answers obtained, the demand curve was constructed which served as a basis for for determining total WTP (Figure 14).

3.4.1 Theoretical background and methodology

Many values of the nature and services offered by the nature (including, for example, ecosystem services) are non-market values. Non-market values are characterized by not having a price developed in the market through the buying-selling process. Therefore, non-market values of the nature do not automatically have monetary equivalent and in order to calculate this, specific economic methods have to be applied, such as, for example, contingent valuation method, which is used to determine the monetary equivalent of the ecosystem service under study.

Every person's assessment to their life includes an assessment to their standard of living and non-market benefits they perceive, appreciate and consider necessary. In theory, every person can evaluate what part of his/her income he/she is willing to sacrifice (how much he/she wants to spend) for which non-economic benefit – with the ultimate aim of raising the individual well-being. This results in economic equivalents of each non-economic benefit, which are different for each person and also changing in time.

Individuals' economic evaluation of the non-market value of nature is demonstrated by their willingness to pay for the preservation or recovery of a natural object as a value carrier. Methodically correctly estimated willingness to pay provides information on monetary equivalents of ecosystem services.

Contingent valuation is a widely used and recognized method for determining the monetary equivalent of non-market environmental goods. Contingent valuation method was first applied in 1963 when Davis tried to assess the value of wildlife among hunters and tourists. In the mid-1970s, the contingent valuation method began to spread rapidly. Since then, the method has become more and more popular and is widespread in many developed countries as a useful tool for making democratic but at the same time economically efficient decisions. Although some aspects of the method have been debated (Eberle, WD and Hayden, FG, 1991), (Harrison, GW and Lesley, JC, 1996), (Nunes, P and van der Bergh, J, 2001), in the absence of alternatives (Diamond, PA and Hausman, JA, 1994), the method has been widely used for determining the monetary equivalents of non-market benefits created by natural assets in the last decades; for example (Franco et al., 2001), (Lee, C.-K. and Han, S.-Y, 2002), (Amigues et al., 2002) (Bandara, R and Tisdell, C, 2003) and (Holmes et al., 2002). Et al, 2004).[119]

The theory of environmental economics considers *contingent valuation* to be very reliable in evaluating non-market goods and services of nature to determine the monetary equivalent of their value. It is also a universal method that can be applied to determine the monetary equivalent of very different types of non-market environmental goods. Despite its widespread use in academic research, the method has a major disadvantage – a need for costly specialized studies in every application of the method. Contingent

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Eberle, W.D and Hayden, F.G. 1991. Critique of Contingent Valuation and Travel Cost Methods for Valuing Natural Resources and Ecosystems. *Journal of Economic Issues.* 1991. a., Kd. 25, 3.

Harrison, G.W and Lesley, J.C. 1996. Must Contingent Valution Surveys Cost So Much?

Journal of Environmental Economics and Management . 1996. a., 31.

Nunes, P and van der Bergh, J. 2001. Economic valuation of biodiversity: sense or nonsense? *Ecological Economics.* 2001. a., 39.

Franco et al. 2001. The role of agroforestry networks in landscape socioeconomic processes: the potential and limits of the contingent valuation method. *Landscape and Urban planning.* 2001. a., Kd. 55, 4.

Lee, C.-K. and Han, S.-Y. 2002. Estimating the Use and Preservation Values of National Parks' Tourism Resources Using a Contingent Valuation Method. *Tourism Management.* 2002. a., Kd. 23, 5.
Amigues et al. 2002. The benefits and costs of riparian analysis habitat preservation: a willingness to accept/willingness to pay contingent valuation approach. *Ecological Economics.* 2002. a., Kd. 43, 1.

Bandara, R and Tisdell, C. 2003. Comparison of rural and urban attitudes to the conservation of Asian elephants in Sri Lanka: empirical evidence. *Biological Conservation.* 2003. a., Kd. 110, 3.
Holmes et al. 2004. Contingent valuation, net marginal benefits and the scale of riparian ecosystem restoration. *Ecological Economics.* 2004. a., Kd. 49, 1.

Mitchell, R and Carson, RT 1990. *Using Surveys to Value Public Goods.* Washington, D.C.: Resources for the Future, 1990.

Carson, R.T. 2011. *Contingent Valuation: A Comprehensive Bibliography and History.* s.l.: Edward Elgar Publishing Inc, 2011.

valuation methodology is thoroughly discussed in “Using Surveys to Value Public Goods” (Mitchell, R and Carson, RT, 1990) and “Contingent Valuation. *A Comprehensive Bibliography and History“(*Carson, 2011).

In Estonia, contingent valuation method has so far been applied, for example, to determine the monetary equivalent of the values of semi-natural grasslands (Ehrlich, Ü and Habicht, K, 2001), Jägala waterfall (Ehrlich, Ü, Reimann, M, 2010) and shores in natural condition (Reimann, M, Ehrlich, Ü, 2012), as well as protected species (Reimann, M., Ehrlich, 2011) and biological habitats (Lepasaar, H, Ehrlich, Ü, 2015).[120]

Contingent valuation method lies in interviewing the members of a representative sample (in this study, for example, the working-age population of Estonia) about their willingness to pay for the non-market environmental goods being studied. Before answering the questions about their willingness to pay, the respondent must be given adequate information about the values for which their willingness to pay is measured. In addition to the willingness to pay, the respondent is also interviewed about their sociometric indicators. The survey is anonymous. The survey was conducted in such a way that the interviewer met directly with the respondent. Telephone and internet surveys were not used.

3.4.2 Willingness to pay for ecosystem services of Estonian grasslands

A contingent valuation (CV) survey was conducted to find out willingness to pay (hereinafter WTP) for ecosystem services of Estonian grasslands. The CV questionnaire included a simulated market scenario, guidance questions, a WTP question and a sociometric section.

An open end WTP 130question was : „I agree to pay … € per year for maintaining Estonian meadows“. The authors anticipated that it was easier for respondents to rank ecosystem services than to declare willingness to pay for each service separately. To simplify answering respondents were not asked to declare WTP for each ecosystem service individually but for grassland ecosystem services as a whole. Later, individual services were attributed value by dividing the entire WTP for meadow ecosystem services according to respondents` preference. In addition to the WTP question, the questionnaire contained a number of guiding questions on respondents’ awareness and frequency of visiting the meadows.

The survey was conducted among Estonian adult population. The total number of adult population, according to ESA, was 107037 (as of 01.01.2018). The simple random sampling method was used. 414 correctly completed questionnaires were received. 338 (82 %) of the respondents are hypothetically willing to pay for the ecosystem services of Estonian grasslands. Population of Estonia with positive WTP (extrapolated) is 873881. Considering the percentage of respondents having positive WTP, one answer can be extrapolated to 2586 inhabitants.

[120] **Ehrlich, Ü, Reimann, M. 2010.** “Hydropower versus Non-market Values of Nature: a Contingent Valuation Study of Jägala Waterfalls, Estonia. *International Journal of Geology.* 2010. a., Kd. 4, 3.

Reimann, M, Ehrlich, Ü. 2012. Public Demand for Shores in Natural Condition: a Contingent Valuation Study in Estonia. *International Journal of Geology*. 2012. a., Kd. 6, 1.

Lepasaar, H, Ehrlich, Ü. 2015. Non-market value if Estonian semi-natural grasslands: a contingent valuation study. *Estonian Discussion of Economic Policy*. 2015. a., Kd. 23, 2.

Based on the results obtained, the demand curve was constructed and based on this the total WTP was determined (Figure 14). Graphically the aggregate WTP is equal to the space under the line on Figure 14. On the Y-axis there are WTP amounts (unit 1000 EUR) and on the x-axis the number of people who are willing to pay at least that amount.

Thus, in order to present the demand function analytically we find the best approach:

$$WTP=\alpha e^{-\beta x} \qquad (1)$$

where WTP is the aggregate willingness to pay, x is the number of individuals who are willing to pay at least that sum, and a and b are the estimated parameters.

On the basis of the parameter estimates we can present the demand curve as follows:

$$WTP=75.058e^{-0,004x} \qquad (2)$$

which is graphically presented in Figure 14.

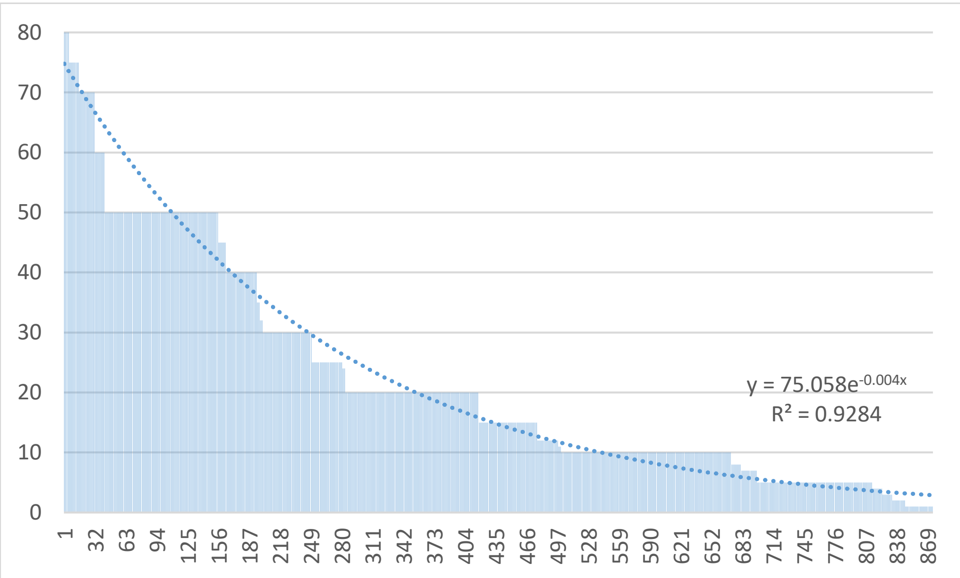

Figure 14. Total willingness to pay for ecosystem services provided by Estonian grasslands per year. On the Y-axis there are WTP amounts (unit 1000 EUR) and on the x-axis the number of people who are willing to pay at least that amount.

In order to find the aggregated WTP estimate the area under the line must be calculated, which is done by line integrating the demand curve according to the formula

$$CS=\int_{x_1}^{x_2} WTP(x)dx=\int_{x_1}^{x_2} \alpha e^{-\beta x}dx=-\frac{\alpha}{\beta}(e^{-\beta x_2}-e^{-\beta x_1})\cong\frac{\alpha}{\beta} \quad , \qquad (3)$$

where x1 is 0 and x2 denotes the number of people with positive willingness to pay.

Calculating the integral according to the above formula the result is:

WTP_T = α/β = 75,058/0,004 = 18764.5 thousand € (4)

Therefore, total annual WTP of Estonian adult population for ecosystem services provided by Estonian grasslands is 18.76 million €. According to the contingent valuation methodology, this can be considered as the annual monetary equivalent of the ecosystem value of Estonian grasslands.

3.4.2.1 Ranking of grassland ecosystem services and WTP assignment according to the ranking results

Another important part of the survey was to identify respondents' preferences and using it WTP for individual ecosystem services.

To do this, respondents were asked to rate the 11 most characteristic ecosystem services of grasslands and rank them in order of subjective importance (1- the most important … 11-least important). In selection of ecosystem services provided by the grasslands the authors did not favour any group of services, and therefore the broadest possible range of services was presented. Grassland ecosystem services to be evaluated and the ranking results for ecosystem services are shown in Table 51.

The column "Average" in the Table 51 shows the average values of the respondents' estimates of ecosystem services. The "Points" column shows the sum of all respondents' points for a particular ecosystem service.

Considering, that the survey scale was structured so that services respondents consider to be more important receive fewer points (1 point denotes the most important service), for ease of calculation, the inverse value of the service scores are presented in the „Inverse „column (Table 51). The next column "Per cent" shows the relative importance of ecosystems calculated using inverse values. In the last column, total WTP is divided between ecosystem services according to respondents' preferences.

Table 51. WTP distributed between ecosystem services considered respondents` preferences.

Ordered by importance	**Average**	**Points**	**Inver-se**	**Per cent**	**WTP Thousand €**
Habitat conservation for biological species	3,72	1258	17,7	13,9	2 610,7
Climate control	4,80	1622	13,7	10,8	2 024,8
Photosynthesis (production of oxygen)	4,88	1651	13,5	10,6	1 989,2
Ensuring landscape diversity	5,16	1740	12,8	10,1	1 887,5
Maintaining soil fertility	5,18	1751	12,7	10,0	1 875,6
Provision of genetic and medical resources	6,27	2118	10,5	8,3	1 550,6
Enabling pollination and honey harvesting	6,31	2134	10,4	8,2	1 539,0
Supply of agricultural production	6,81	2302	9,7	7,6	1 426,7
Flood protection	6,99	2364	9,4	7,4	1 389,3
Enabling environmental education	7,64	2583	8,6	6,8	1 271,5
Provision of tourism and leisure services	8,10	2738	8,1	6,4	1 199,5
TOTAL		22261	127,2	100,0	18 764

Respondents considered to be the most important ecosystem service of grasslands „Habitat conservation for biological species", with an annual WTP of 2.61 million €. Following services were

„Climate control“and Photosynthesis (production of oxygen)“, with WTP of approximately 2 million €. It is worth noting that all three of the higher-rated values belong to the non-anthropocentric instrumental type of value (SEE EA discussion paper 5.1, p 30) In fourth place was the value „Ensuring landscape diversity" (WTP 1.9 million €), which can be considered as aesthetic value.

Grassland ecosystem service relating to agriculture „Supply of agricultural production” is ranked 8th in respondents' preference (total WTP $ 1.4 million). This indicates that grassland provisioning services are not perceived by respondents as very important compared to other services.

The service “Flood protection” is also ranked relatively low (WTP 1.4 million €). The ranking of this service is low probably due to the fact that floods are not a very topical issue in Estonia and occur rarely and a limited geographically.

Surprisingly, services “Enabling environmental education” and “Provision tourism and leisure services” remain in the last two places (total attributed WTP respectively 1.3 and 1.2 million €). These are services which value will have a positive impact on well-being in case of direct human contact with the ecosystem.

In conclusion, Estonian inhabitants value the biological regulation and global life support ecosystem services of grasslands higher compared to recreational and educational ecosystem services. This may be so due to the fact that Estonian inhabitants are relatively well aware of the global environmental problems and the need for the protection of biological species, but are relatively not often in direct contact with grasslands.

3.4.3 Limitations of contingent valuation study

Contingent valuation is one of the rare methods of valuing non-market values that seeks to evaluate values through their impact on the well-being of individuals.

From a statistical and accounting point of view, the disadvantage of the results obtained by this method lies in the fact, that although the results reflect the true ability of quantified non-market values to influence positively the well-being of individuals, the identified monetary equivalent using CVM is not based on actual expenditure and therefore on actual turnover. This fact makes the usability of monetary equivalent of the ecosystem services found by the CVM method problematic in statistics.

3.4.4 Distribution of WTP between semi-natural and cultivated grasslands

The CVM questionnaire also contained a question in which respondents could rank different types of grasslands according to their (subjective) importance. The list of grassland types in the questionnaire was not exhaustive, but included the three best-known semi-natural grassland types (wooded meadow, coastal meadow, river (alluvial) meadow) and in addition to these cultivated grassland. Ranking grasslands by respondents according to their importance makes possible to allocate WTP for grassland ecosystem services between semi-natural grasslands and cultivated grasslands (Table 52).

Table 52. WTP for semi-natural and cultivated grasslands

Ecosystem service (odered by amount WTP)	WTP Thousand €	including	
		Semi-natural grassland	Cultivated grassland
Habitat conservation for biological species	2610.7	2039.5	571.2
Climate control	2024.8	1581.8	443.0
Photosynthesis (production of oxygen)	1989.2	1554.0	435.2
Ensuring landscape diversity	1887.5	1474.5	413.0
Maintaining soil fertility	1875.6	1465.3	410.4
Provision of genetic and medical resources	1550.6	1211.3	339.3
Enabling pollination and honey harvesting	1539.0	1202.3	336.7
Supply of agricultural production	1426.7	1114.5	312.2
Flood protection	1389.3	1085.3	304.0
Enabling environmental education	1271.5	993.3	278.2
Provision of tourism and leisure services	1199.5	937.1	262.4
TOTAL	18764.4	14658.9	4105.6
%	100.00	78	22

78% of total WTP is attributable to semi-natural grasslands and 22% to cultivated grasslands, expressed in monetary terms of 14.7 million € and 4.1 million € respectively.

The big difference in WTP is probably due to the fact that positive emotions and knowledge about ecosystem services related to grasslands are mainly associated with semi-natural grasslands, the importance of which has been widely discussed in the media. Cultivated grasslands are more associated with agriculture, which is more likely to be associated with environmental problems.

Considering that the list of grassland types in the CVM questionnaire was not exhaustive, the distribution of WTP among different grassland types needs further investigation.

3.5 Supply of the ecosystem services by grassland types, selected preferred methods and aggregation of the values

3.5.1 Supply of the ecosystem services, parallel methods

If for country level macroeconomic assessments of the total flows of ecosystem services the spatial dimension and defining of the area which is supplying the service are not important than for analyses which are dealing with relative importance of a specific ecosystems or ecosystem types in provisioning of certain services or for the analyses which handle the spectrums of the services provided by single ecosystem types, - the spatial dimension is important.

In current work, we have in most cases estimated service value in total i.e. at country level and in later stages made an effort to distinguish between different ecosystems contributions to total annual service values and to create the spatial allocation of the service. The ecosystem service provisioning area was handled for each service separately. We found total hectare value by summing up of the average ecosystem service values (eight ecosystem services) per grassland type.

In case of the regulative ecosystem services, where actual and potential supply meet, the distribution of the service value by service providing areas (grassland ecosystem types) is straightforward and the ecosystem contribution was modelled using spatial analysis. For example, the climate control ecosystem service (provisioning of the carbon sequestration stock maintenance ecosystem service for different grasslands types) was modelled using data for Estonia soil types and ecosystem unit map.

For the ecosystem services for which provisioning areas were known or identified (nature education, nature recreation, recreational hunting), the calculation of the ecosystem service values for grasslands was carried out based on the composition of the ecosystems in service provisioning ecosystems. .

In several cases, when the spatial distribution of the actual supply was not known, the feasibility of the application of intermediate approach i.e. dividing results obtained from top-down approach to multiple aggregate level (grassland types) values based on qualitative indicators, were discussed with experts. This was used for example for fodder production ecosystem service, where yield factors and soil fertility factors of grasslands were used. In certain cases it was not possible to link the service to a specific ecosystem type. The data and statistics for the identification of the actual supply of the service about spatial distribution were not available for provisioning of medicinal herbs and game ecosystem services. In these cases, aggregate value found by using the exchange values method was distributed between the ecosystems according to the best estimates of service provisioning grassland types. This kind of distribution does not reflect the actual ecosystem service supply, therefore it should be noted that in these cases the calculated actual supply of the service may not have adequate spatial distribution.

Understanding the difference between actual and potential supply would be exceedingly relevant in next year's work when the actual and potential supply for example for timber and later for peat would be handled.

Regarding the allocation of the valuation results obtained from contingent valuation method, the allocation of actual supply categories by the ecosystem types was considered methodologically not feasible due to the initial construction of the CVM questionnaire and the structure of data.

Table 53 displays the supply of ecosystem services by grasslands types which were obtained by main parallel methods and illustrates the differences in the ranges of ecosystem service values that may fluctuate depending of the method selected. Not all results of the parallel methods are presented in table, the selection of the preferred methods is described in the respective chapters of valuing ecosystem services.

Table 53. The supply of ecosystem services by grasslands types, thousand €

	Grassland type	Fodder (rent price)	Fodder (hybrid method)	Hay for bioenergy (market price)	Medical herbs (market price)	Game (market price)	C sequestration (EUA price)	C storage (CVM)	Pollination (avoided damage cost)	Pollination (benefit transfer)	Nature education (cost based approach, distributed by visitation	Nature education (cost based approach, distributed by ecosystem	Nature education (CVM)	Hunting (cost based approach)	Recreation (time use)	Recreation (CVM)
1.	Grassland	25 989	2 042	51	191	1 151	0	2 024	7 617	6 906	753	753	1 272	2 222	5 305	1 200
1.1.	Semi-natural grassland	5 198	408	51	125	557	0	1 580	3 358	3 048	632	632	993	1 068	3 070	937
1.1.1.	Semi-natural grassland according to the NATURA classification	2 085	164	51	55	263	0		953	865	283	283		470	1 374	
1.1.1.1.	Boreal baltic coastal meadows	242	34	0	17	69	0		0	0	27	27		111	163	
1.1.1.2.	Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	3	1	0	0	1	0		3	2	2	2		1	20	
1.1.1.3.	Dry sand heaths with Calluna and Empetrum nigrum	1	0	0	0	0	0		0	0	0	0		0	0	
1.1.1.4.	Inland dunes with open Corynephorus and Agrostis	0	0	0	0	0	0		0	0	0	0		0	0	
1.1.1.5.	European dry heaths	5	1	0	0	1	0		6	5	2	2		2	22	
1.1.1.6.	Juniperus communis formations on heaths or calcareous grasslands	63	6	0	0	14	0		38	35	10	10		24	23	
1.1.1.7.	Xeric sand calcareous grasslands	1	0	0	0	0	0		1	0	0	0		0	0	
1.1.1.8.	Calaminarian grasslands of the Violetaliacalaminariae	0	0	0	0	0	0		0	0	0	0		0	0	
1.1.1.9.	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	102	9	0	9	15	0		161	146	14	14		28	69	
1.1.1.10.	Fennoscandian lowland species-rich dry to mesic grasslands	134	10	0	3	14	0		103	93	30	30		24	101	
1.1.1.11.	Nordic alvar and precambrian calcareous flatrocks	229	25	0	11	56	0		340	308	48	48		98	77	
1.1.1.12.	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	68	6	0	0	11	0		31	28	3	3		15	22	
1.1.1.13.	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	82	6	0	0	7	0		12	11	17	17		15	69	
1.1.1.14.	Northern boreal alluvial meadows	635	44	51	3	43	0		43	39	75	75		90	625	
1.1.1.15.	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	116	9	0	3	11	0		27	24	31	31		20	124	
1.1.1.16.	Fennoscandian wooded meadows	102	8	0	6	11	0		91	83	9	9		23	45	
1.1.1.17.	Fennoscandian wooded pastures	61	5	0	2	10	0		98	89	14	14		17	15	
1.1.2.	Other semi-natural grassland	3 355	245	0	70	294	0		2 406	2 184	348	348		598	1 695	
1.2.	Cultivated grassland	20 791	1 634	0	66	594	0	444	4 259	3 858	121	122	278	1 153	2 235	262
1.2.1.	Permanent grassland	20 791	1 634	0	66	594	0		4 259	3 858	121	122		1 153	2 235	
1.2.1.1.	Environmental non-sensitive permanent grassland	20 744	1 630	0	66	593	0		4 250	3 849	120	121		1 151	2 228	
1.2.1.2.	Environmental sensitive permanent grassland	47	4	0	0	1	0		9	8	1	1		3	7	

3.5.2 Supply of ecosystem services, preferred methods and aggregation of service values

Calculations of valuation of selected ecosystem services have been done in parallel with various methods (Table 53). In order to compile the experimental total ecosystem service values per grassland type, the selection of the best valuation option for each ecosystem service was discussed (based on subjective preferences and agreement between experts on a final seminar of current work held on November 27 and 28 in Statistics Estonia[121]). Table 54 displays the values for ecosystem services on different levels of grassland types and the chosen valuation method. Both the methods and the preference may change in later stages of development of an ecosystem accounts, so the results should be treated carefully. Carbon stock provisioning service was left out of the total values as it was agreed that carbon stock service is not like sequestration service that can be calculated per hectare per year, but a stock service that does not change over time. There is a need for further methodological discussion on how to handle this service along with the services which value is supplied during one year. The total service value should be handled as a total of eight ecosystem services valued and these do not represent the total value of all provided ecosystem services. Table 54 shows the monetary values of ecosystem services calculated in this work by different types of grasslands.

Table 54. Supply of ecosystem services for grassland types, selected methods and total value for eight selected services, thousand €, 2018

	Ecosystem type	Fodder (rent price)	Hay for bioenergy (market price)	Medical herbs (market price)	Game (market price)	C sequestration (EUA price)	Pollination (benefit transfer)	Nature education (cost based approach, distributed by visitation	Hunting (cost based approach)	Recreation (time use)	**Total service value**
1.	Grassland	25 989	51	191	1 151	0	6 906	753	2 222	5 305	42 567
1.1.	Semi-natural grassland	5 198	51	125	557	0	3 048	632	1 068	3 070	13 748
1.1.1.	Semi-natural grassland according to the NATURA classification	2 085	51	55	263	0	865	283	470	1 374	5 446
1.1.1.1.	Boreal baltic coastal meadows	242	0	17	69	0	0	27	111	163	628
1.1.1.2.	Fixed coastal dunes with herbaceous vegetation ("grey dunes")	3	0	0	1	0	2	2	1	20	30
1.1.1.3.	Dry sand heaths with Calluna and Empetrum nigrum	1	0	0	0	0	0	0	0	0	1
1.1.1.4.	Inland dunes with open Corynephorus and Agrostis	0	0	0	0	0	0	0	0	0	1
1.1.1.5.	European dry heaths	5	0	0	1	0	5	2	2	22	36
1.1.1.6.	Juniperus communis formations on heaths or calcareous grasslands	63	0	0	14	0	35	10	24	23	168
1.1.1.7.	Xeric sand calcareous grasslands	1	0	0	0	0	0	0	0	0	1
1.1.1.8.	Calaminarian grasslands of the Violetaliacalaminariae	0	0	0	0	0	0	0	0	0	0
1.1.1.9.	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	102	0	9	15	0	146	14	28	69	383
1.1.1.10.	Fennoscandian lowland species-rich dry to mesic grasslands	134	0	3	14	0	93	30	24	101	399
1.1.1.11.	Nordic alvar and precambrian calcareous flatrocks	229	0	11	56	0	308	48	98	77	827
1.1.1.12.	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	68	0	0	11	0	28	3	15	22	148
1.1.1.13.	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	82	0	0	7	0	11	17	15	69	202
1.1.1.14.	Northern boreal alluvial meadows	635	51	3	43	0	39	75	90	625	1 560
1.1.1.15.	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	116	0	3	11	0	24	31	20	124	330
1.1.1.16.	Fennoscandian wooded meadows	102	0	6	11	0	83	9	23	45	279
1.1.1.17.	Fennoscandian wooded pastures	61	0	2	10	0	89	14	17	15	209
1.1.2.	Other semi-natural grassland	3 355	0	70	294	0	2 184	348	598	1 695	8 545
1.2.	Cultivated grassland	20 791	0	66	594	0	3 858	121	1 153	2 235	28 819
1.2.1.	Permanent grassland	20 791	0	66	594	0	3 858	121	1 153	2 235	28 819
1.2.1.1.	Environmental non-sensitive permanent grassland	20 744	0	66	593	0	3 849	120	1 151	2 228	28 752
1.2.1.2.	Environmental sensitive permanent grassland	47	0	0	1	0	8	1	3	7	68

[121] Annex 2 provides the summary of the seminar.

3.5.2.1 The analysis of the service values

The total value of eight grasslands ecosystem services that we considered, was 42.6 million € and it should be handled as a total for given services measured and based on given assumptions and methods and do not represent the total value of all provided ecosystem services. From this total value of ecosystem services, the production of fodder as ecosystem service contributed 26 million € and gave the largest share (61%) of grasslands services. Pollination ecosystem service contributed 6.9 million € (16%) and recreation service 5.3 million € (12%).

The comparison of the ecosystems on the bases of these eight services values and considering current assumptions show that semi-natural and cultivated grasslands differ in the service provisioning capacity: cultivated grasslands contributed 28.9 million € and semi-natural grasslands contributed 13.7 million € of the total grassland ecosystem service value. So the value of the ecosystem services provided by cultivated grasslands exceeds the value of semi-natural grassland by 15.2 million €.

Regarding the high provided service value of the cultivated grasslands, it is obvious that fodder production ecosystem service contributes most to the total value of the services provided by these grasslands. Cultivated grasslands also contribute remarkably for pollination and hunting ecosystems services supply in absolute terms. This is because the area of the cultivated grasslands is also larger than semi-natural grasslands in Estonia. Higher fodder production of cultivated grasslands is to be expected, since the cultivated grasslands are agricultural ecosystems which purpose is mainly fodder production. For fodder the share of cultivated grassland contribution exceeded the semi-natural grasslands by 16 million € (80%), in case of pollination service, provisioning of the service by cultivated grasslands is 56% out of grasslands total contribution. For the valuation of the services for which market prices exist (e.g. fodder production) WTP is not relevant and these figures are not compared here.

In case of hay for bioenergy, medical herbs, pollination, nature education and recreation ecosystem services, the contribution of the semi-natural grasslands was larger than cultivated grasslands. Semi-natural grasslands contributed 100% of the total grasslands service value of biomass for bioenergy, 65% of the ecosystem service value for medical herbs, 84% of service value of nature education and 58% of the value of the recreation ecosystem service.

Regarding NATURA semi-natural grassland habitats, the largest contributors to the total value of eight ecosystem services are northern boreal alluvial meadows which are distinguished by their relatively high contribution of the fodder production and Nordic alvar and precambrian calcareous flat rocks which could be distinguished by their higher provision of fodder production and pollination ecosystem service. Boreal Baltic coastal meadows are distinguished by their general relatively higher values of providing several ecosystem services.

Comparing cultivated and semi-natural grassland ecosystem services, it can be argued that both play an important role in providing ecosystem services but in different ways.

The interpretation of the results should be done with caution and care in current experimental phase. For example, looking at the different calculations of the service values of grassland ecosystem services, there are two alternative values for fodder production ecosystem service: one is found using rent price method (26 million €) and other alternative fodder ecosystem service value is found by using the hybrid method (5 million €). Service counts for about 80% of the total value, if measured by first method. It is evident that both the total value of grassland ecosystem services and the proportions of the value between cultural and semi-natural grassland ecosystem services depend on how the value of the service under question was found and accounted.

3.5.2.2 Comparison of the results obtained by preferred methods with the WTP method results

If in case of the WTP, 78% of total is attributable to semi-natural grasslands and 22% to cultivated grasslands, expressed in monetary terms of 14.7 million € and 4.1 million € respectively than in case of preferred methods 80% could be attributed to cultivate and 20% to semi-natural grasslands.

The total value of ecosystem services in case of the selected preferred methods was 42.5 million and in case of WTP 19 million.

Considering the nature and content of the contingent valuation method (CVM), which identifies how much the environmental goods influence (positively) the respondent's well-being, the difference between the values found using CVM and values identified using other valuation methods is not surprising. The total WTP for the grassland ecosystem services found by the CVM method, approximately €20 million €, is smaller compared the value found by other methods (approximately 42 million €). Table 55 shows the comparison of the results obtained by the selected preferred methods to the WTP method results.

Table 55. Comparison of the results obtained by the selected preferred methods to the WTP method results, million €, shares.

	Sum of the grassland ecosystem services of the selected preferred methods, €	Share of the grasslands sub-categories in the sum of the services of the selected services and preferred methods, %	Sum of the grassland ecosystem services, €according to WTP method	Share of the grasslands sub-categories in the sum of the services according to WTP method %
Cultivated grasslands	50.7	80%	14.7	22%
Semi-natural grasslands	13.7	20%	4.1	78%
Total	42.6		18.8	

The different distribution of the total value of the ecosystem services found by CVM between cultivated and semi-natural grassland compared to the found by other methods may be due to the fact that cultivated grassland is agricultural land in the perception of the people. However, agriculture has a rather polluting image (created during the Soviet era) and people do not associate ecosystem services with agricultural land. This is probably one of the reasons why the value of ecosystem services provided by cultivated grasslands identified using WTP is relatively modest, compared to those found by other methods. Another reason is the simulated market scenario used in the CVM survey, which did not explicitly highlight the ecosystem services of cultivated grassland. However, as already mentioned above, grassland as such is generally understood as semi-natural grassland, the nature conservation value of which is much mentioned in the media and is therefore well known.

Considering that the list of grassland types in the CVM questionnaire was not exhaustive, the distribution of WTP among different grassland types may differ as well.

Most likely, in WTP survey, a variety of grasslands were not described so that the respondents could have given their preference to the accuracy it was expected. And even WTP would have described the different grasslands in WTP survey perfectly, even then the respondents still would not have been able to provide their willingness to pay with the accuracy we would have expected.

Consider that cultural grasslands offer more services than semi-natural grasslands, the "key" to this issue could be simply the fact that in current study Statistics Estonia mainly valued provisioning and cultural services (services that are directly used). But semi-natural grasslands provide, in particular lot of regulatory and maintenance services (biodiversity, species preservation, etc.) which were not assessed.

Figure 15 shows the comparison of the results (service value in million €) for the same services obtained by the selected preferred methods or by using the WTP method.

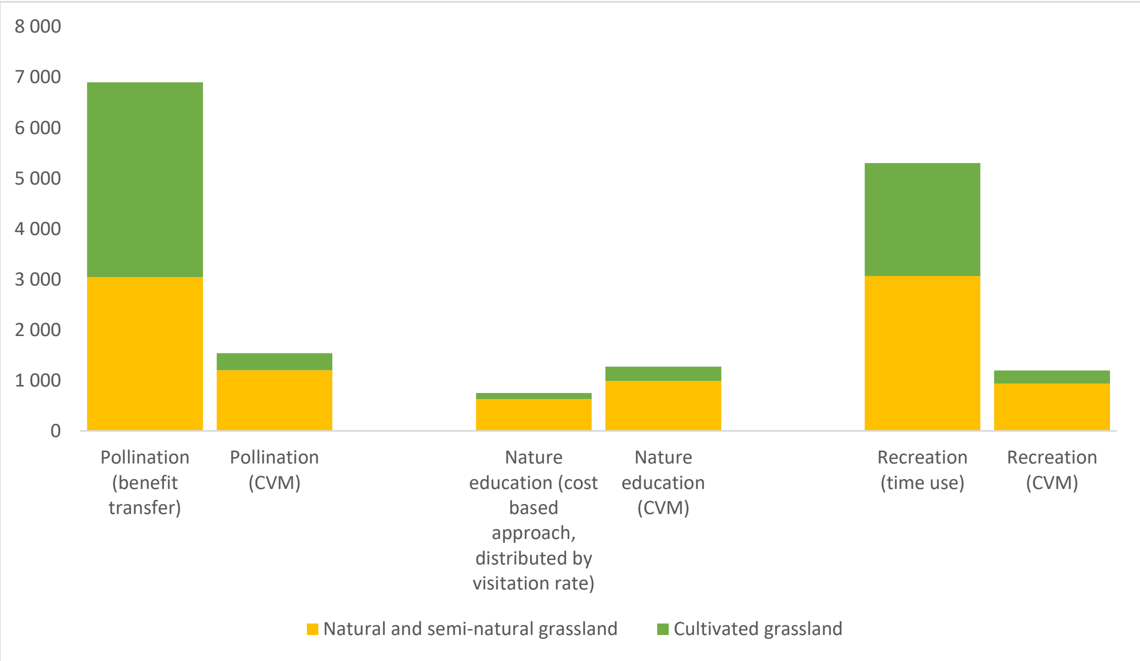

Figure 15. Comparison of the results (service value in million €) obtained by the selected preferred methods and WTP method for recreation, nature education and pollination ecosystem services.

3.5.3 Compilation of the average hectare values for ecosystem services per grassland type

We have also calculated the hectare-based values to provide a better comparison of cultivated and semi-natural grasslands. Table 56 shows an average ha value for ecosystem services which are calculated by several parallel methods.

Table 56. Average ha values for ecosystem services (several parallel methods), € per ha

	Grassland type	Fodder (rent price)	Fodder (hybrid method)	Hay for bioenergy (market price)	Medical herbs (market price)	Game (market price)	C sequestration (EUA price)	C storage (CVM)	Pollination (avoided damage cost)	Pollination (benefit transfer)	Nature education (cost based approach,	Nature education (cost based approach,	Nature education (CVM)	Hunting (cost based approach)	Recreation (time use)	Recreation (CVM)
1.	Grassland	52.1	4.1	0.1	0.4	2.3	0.0	4.1	15.3	13.9	1.5	1.8	2.6	4.5	10.6	2.4
1.1.	Semi-natural grassland	21.5	1.7	0.2	0.5	2.3	0.0	6.5	13.9	12.6	2.6	2.5	4.1	4.4	12.7	3.9
1.1.1.	Semi-natural grassland according to the NATURA classification	21.5	1.7	0.5	0.6	2.7	0.0		9.8	8.9	2.9	4.3		4.8	14.2	
1.1.1.1.	Boreal baltic coastal meadows	12.1	1.7	0.0	0.8	3.4	0.0		0.0	0.0	1.4	5.1		5.6	8.1	
1.1.1.2.	Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	6.8	1.7	0.0	0.2	2.9	0.0		6.6	6.0	6.1	26.3		3.7	50.5	
1.1.1.3.	Dry sand heaths with Calluna and Empetrum nigrum	15.3	1.7	0.0	0.0	3.2	0.0		10.0	9.0	0.0	0.0		5.1	0.0	
1.1.1.4.	Inland dunes with open Corynephorus and Agrostis	0.5	1.7	0.0	0.7	3.8	0.0		13.3	12.1	0.0	0.0		4.5	2.5	
1.1.1.5.	European dry heaths	8.6	1.7	0.0	0.0	1.8	0.0		10.0	9.0	2.8	4.9		3.7	38.8	
1.1.1.6.	Juniperus communis formations on heaths or calcareous grasslands	16.4	1.7	0.0	0.0	3.5	0.0		10.0	9.0	2.7	5.2		6.3	5.9	
1.1.1.7.	Xeric sand calcareous grasslands	18.2	1.7	0.0	0.0	4.3	0.0		16.6	15.1	0.0	0.0		5.1	0.0	
1.1.1.8.	Calaminarian grasslands of the Violetaliacalaminariae	21.8	1.7	0.0	0.0	2.5	0.0		16.6	15.1	0.0	0.0		6.2	0.0	
1.1.1.9.	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	18.9	1.7	0.0	1.7	2.7	0.0		29.9	27.1	2.6	4.5		5.3	12.9	
1.1.1.10.	Fennoscandian lowland species-rich dry to mesic grasslands	21.6	1.7	0.0	0.5	2.2	0.0		16.6	15.1	4.9	3.0		3.9	16.4	
1.1.1.11.	Nordic alvar and precambrian calcareous flatrocks	15.7	1.7	0.0	0.8	3.8	0.0		23.2	21.1	3.3	7.1		6.7	5.3	
1.1.1.12.	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	18.5	1.7	0.0	0.1	2.9	0.0		8.3	7.5	0.7	1.4		4.2	6.1	
1.1.1.13.	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	22.5	1.7	0.0	0.1	2.1	0.0		3.3	3.0	4.6	4.5		4.1	19.0	
1.1.1.14.	Northern boreal alluvial meadows	24.6	1.7	2.0	0.1	1.7	0.0		1.7	1.5	2.9	2.4		3.5	24.2	
1.1.1.15.	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	21.7	1.7	0.0	0.6	2.0	0.0		5.0	4.5	5.9	6.1		3.7	23.2	
1.1.1.16.	Fennoscandian wooded meadows	22.4	1.7	0.0	1.3	2.5	0.0		19.9	18.1	2.0	3.6		5.0	9.8	
1.1.1.17.	Fennoscandian wooded pastures	20.6	1.7	0.0	0.7	3.5	0.0		33.2	30.1	4.7	2.6		5.7	5.1	
1.1.2.	Other semi-natural grassland	23.2	1.7	0.0	0.5	2.0	0.0		16.6	15.1	2.4	1.3		4.1	11.7	
1.2.	Cultivated grassland	81.2	6.4	0.0	0.3	2.3	0.0	1.7	16.6	15.1	0.5	1.2	1.1	4.5	8.7	1.0
1.2.1.	Permanent grassland	81.2	6.4	0.0	0.3	2.3	0.0		16.6	15.1	0.5	1.2		4.5	8.7	
1.2.1.1.	Environmental non-sensitive permanent grassland	81.2	6.4	0.0	0.3	2.3	0.0		16.6	15.1	0.5	1.2		4.5	8.7	
1.2.1.2.	Environmental sensitive permanent grassland	85.7	6.4	0.0	0.3	1.7	0.0		16.6	15.1	1.3	5.0		4.7	13.2	

It should be kept in mind, that the values per hectare found by the various methods could be aggregated as well. The compilation of the average ecosystem service values per grassland types was demonstrated for selected eight ecosystem services. In Table 57 only the results of the preferred methods and total sum of average values of the services per ha is displayed.

Calculated average hectare-based values based of these eight selected services provide a better comparison of cultivated and semi-natural grasslands as these are more independent of the total area of different ecosystem types. In respect to the specific valuable grasslands ecosystems (seminatural NATURA grassland habitats) it should be noted that cultivated grasslands provide higher total hectare ecosystem service values (113-122 € per ha) due to higher fodder production. Semi-natural grasslands have lower per hectare total values (in average 57 € per ha).

Table 57. Experimental average hectare values of the selected ecosystem services (based on preferred methods) and the sum of the values of the services, € per ha

	Grassland type	Fodder (rent price)	Hay for bioenergy (market price)	Medical herbs (market price)	Game (market price)	C sequestration (EUA price)	Pollination (benefit transfer)	Nature education (cost based approach, distributed by visitation rate)	Hunting (cost based approach)	Recreation (time use)	Total average ha-value
1.	Grassland	52.1	0.1	0.4	2.3	0.0	13.9	1.5	4.5	10.6	85
1.1.	Semi-natural grassland	21.5	0.2	0.5	2.3	0.0	12.6	2.6	4.4	12.7	57
1.1.1.	Semi-natural grassland according to the NATURA classification	21.5	0.5	0.6	2.7	0.0	8.9	2.9	4.8	14.2	56
1.1.1.1.	Boreal baltic coastal meadows	12.1	0.0	0.8	3.4	0.0	0.0	1.4	5.6	8.1	31
1.1.1.2.	Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	6.8	0.0	0.2	2.9	0.0	6.0	6.1	3.7	50.5	76
1.1.1.3.	Dry sand heaths with Calluna and Empetrum nigrum	15.3	0.0	0.0	3.2	0.0	9.0	0.0	5.1	0.0	33
1.1.1.4.	Inland dunes with open Corynephorus and Agrostis	0.5	0.0	0.7	3.8	0.0	12.1	0.0	4.5	2.5	24
1.1.1.5.	European dry heaths	8.6	0.0	0.0	1.8	0.0	9.0	2.8	3.7	38.8	65
1.1.1.6.	Juniperus communis formations on heaths or calcareous grasslands	16.4	0.0	0.0	3.5	0.0	9.0	2.7	6.3	5.9	44
1.1.1.7.	Xeric sand calcareous grasslands	18.2	0.0	0.0	4.3	0.0	15.1	0.0	5.1	0.0	43
1.1.1.8.	Calaminarian grasslands of the Violetaliacalaminariae	21.8	0.0	0.0	2.5	0.0	15.1	0.0	6.2	0.0	46
1.1.1.9.	Semi-natural dry grasslands and scrubland facies on calcareous substrates	18.9	0.0	1.7	2.7	0.0	27.1	2.6	5.3	12.9	71
1.1.1.10.	Fennoscandian lowland species-rich dry to mesic grasslands	21.6	0.0	0.5	2.2	0.0	15.1	4.9	3.9	16.4	65
1.1.1.11.	Nordic alvar and precambrian calcareous flatrocks	15.7	0.0	0.8	3.8	0.0	21.1	3.3	6.7	5.3	57
1.1.1.12.	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	18.5	0.0	0.1	2.9	0.0	7.5	0.7	4.2	6.1	40
1.1.1.13.	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	22.5	0.0	0.1	2.1	0.0	3.0	4.6	4.1	19.0	55
1.1.1.14.	Northern boreal alluvial meadows	24.6	2.0	0.1	1.7	0.0	1.5	2.9	3.5	24.2	60
1.1.1.15.	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	21.7	0.0	0.6	2.0	0.0	4.5	5.9	3.7	23.2	62
1.1.1.16.	Fennoscandian wooded meadows	22.4	0.0	1.3	2.5	0.0	18.1	2.0	5.0	9.8	61
1.1.1.17.	Fennoscandian wooded pastures	20.6	0.0	0.7	3.5	0.0	30.1	4.7	5.7	5.1	70
1.1.2.	Other semi- natural grassland	23.2	0.0	0.5	2.0	0.0	15.1	2.4	4.1	11.7	59
1.2.	Cultivated grassland	81.2	0.0	0.3	2.3	0.0	15.1	0.5	4.5	8.7	113
1.2.1.	Permanent grassland	81.2	0.0	0.3	2.3	0.0	15.1	0.5	4.5	8.7	113
1.2.1.1.	Environmental non-sensitive permanent grassland	81.2	0.0	0.3	2.3	0.0	15.1	0.5	4.5	8.7	113
1.2.1.2.	Environmental sensitive permanent grassland	85.7	0.0	0.3	1.7	0.0	15.1	1.3	4.7	13.2	122

At first glance, the difference is rather large, but it is important, that the majority of the 113 € per hectar value of cultivated grassland comes from fodder production (81.2 € per hectar). From the other services, the pollination ecosystem service of 15.1 € per hectare is also remarkable for cultivated grasslands.

Semi-natural grassland ecosystem services are revealing on a much broader spectrum. Also here, the largest component (over 50% of the total value) is the fodder production ecosystem service provision with (21, 5 € per hectare), but all other services are also represented. The second highest service of semi-natural grasslands is the recreational ecosystem service (12, 7 € per hectare), which value was estimated using value of time.

Fixed coastal dunes with herbaceous vegetation (“grey dunes”) contribute the highest values to the total value of the whole semi-natural grasslands group (76 € per ha) mainly due to the high provision of recreational ecosystem service. Semi-natural dry grasslands and scrubland facies on calcareous substrates show the second highest per hectare value which was mostly influenced by the ability to provide simultaneously high fodder production, pollination service and recreation ecosystem services. Third highest are the Fennoscandian wooded pastures which also show the high fodder production and pollination ecosystem services values. However it should be kept in mind that only selected eight services were valued and several relevant regulative ecosystem services are not accounted for.

According to the contingent valuation method (CVM), the value of climate regulation is 5.8 €/ha, nature education is 3.7 €/ha and recreation is 3.4 €/ha. Over 75% of total willingness to pay is attributable to semi-natural grasslands ecosystem services. The service values found by the CVM method are discussed in more detail in the relevant chapter.

In conclusion, all ecosystem services, except fodder production for semi-natural grasslands have higher or comparable values to cultivated grasslands. This was to be expected, since the maintenance of semi-natural grasslands is mainly subsidized for providing ecosystem services, and not so much to get agricultural production (like fodder), which is indeed more specific to cultivated grasslands.

Northern boreal alluvial meadows contribute the highest values per total of the whole grasslands group (210 € per ha per year). This was mostly influenced by this grassland type ability to provide simultaneously the high carbon stock maintenance, fodder production and recreation ecosystem services. Second highest is the Hydrophilous tall herb fringe communities of plains featuring the same kind of ecosystem service profile.

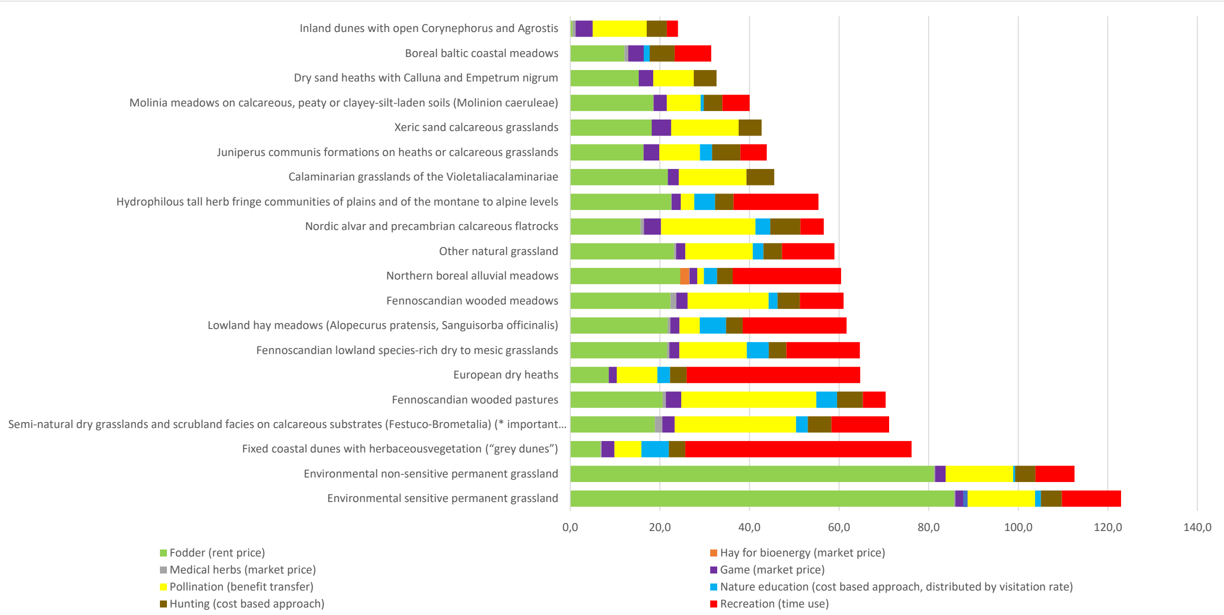

Figure 16. Experimental average hectar values of the selected ecosystem services (preferred method), € per ha

The results and problems of development of the spatial allocation of service provision of the ecosystem services were analysed in project group, discussed in discussions with international experts and also on a seminar involving stakeholders. Regarding the development of the monetary unit values, it was noted by the project experts, that the concepts for the monetary aggregate hectare values both per ecosystem types and per single land parcels, are still very much in development phase and are hindered by the lack of data for actual supply of several services on a detailed spatial scale. It was recognized by the project experts that monetary unit values for ecosystem services could be directly feasible on a general or aggregate level as at specific locations the actual and potential supply might differ and hence the allocation of the service value might be incorrect. The intermediate approach for service values per hectare was proposed as well where the ha-value would be divided into multiple aggregate level values based on qualitative indicators.

Figure 17 displays experimental average hectare values of the selected ecosystem services (preferred method), € per ha.

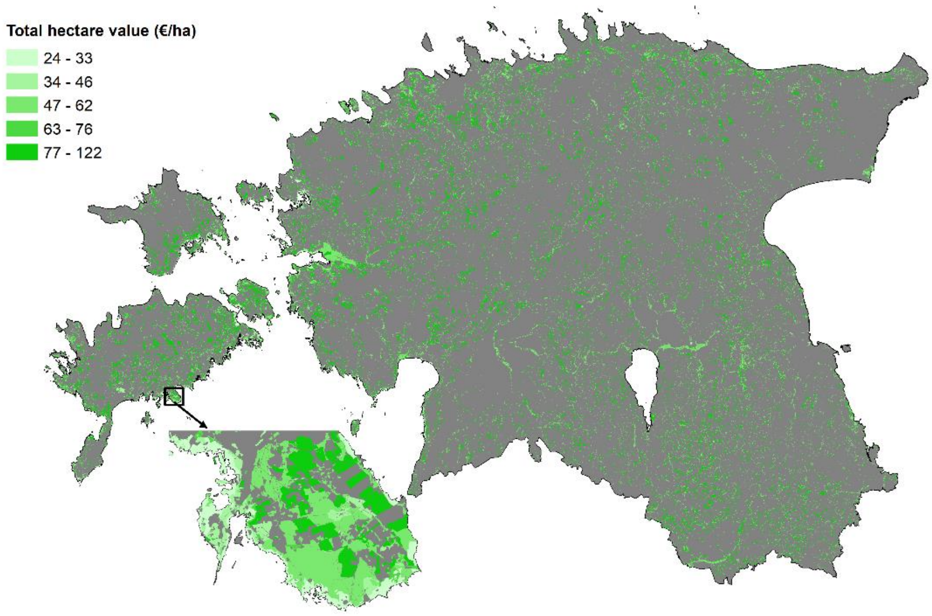

Figure 17. Total of experimental average hectare values of the selected ecosystem services (preferred method), € per ha for Estonian grasslands. The areas coloured in shades of green represent grasslands according to the value they supply as a sum of the basket of selected ecosystem services. Dark grey areas are other ecosystem types that were not analysed in the current work.

The approach that cadastral units should enable to aggregate the services on the level of single cadastral units was primarily considered provoking but due to the data availability of all service flows on such a detailed level it was not considered a relevant general approach. However the cadastral units could still function as a basic mapping and statistical units. Several of the methods for estimation of the physical service flows need further improvement to get the high quality service values on a cadastral level in the future. However, making that detailed level cadastral level information publicly available could be also restricted not just because of spatial level quality but also due to confidentiality rules as several of the input datasets are not for a public use. In case of publication of cadastral level statistics, the confidentiality restriction should be clarified. Apart from single cadastral level approach the aggregating the ecosystem service values per ecosystem types is relevant.

4. Ecosystem services supply and use tables and integration with SNA

4.1 Supply and use table for the ecosystem service values for grasslands

One of the goals of this project was to compile supply and use table for the calculated ecosystem service values. In ecosystem services supply and use table, ecosystems are the suppliers of ecosystem services and users may be all institutional sectors but also other ecosystems, in case of intermediate services (for example pollination). All service values of finally selected service valuation methods were included in the table and users of the ecosystem services were identified.

Supply table is distributed between ecosystem types by ecosystem service. Use is distributed by institutional sectors by ecosystem services. Supply is always equal to use. Both supply and use tables have a separate total column for grasslands and total over the ecosystem types for the whole country. Pollination ecosystem service is treated differently from other services, as it is an intermediate service and it is provided by grasslands to croplands. This is outlined also in following Table 58. No-use values were detected for NPISH and rest of the world but are kept in the table in order to show the structure of table as these institutional sectors could also be the users of certain ecosystem services.

The calculated values of various previously described and ecosystem services listed in Table 54 were included in the supply and use tables and can be seen in Table 58.

Table 58. Supply and use table of grasslands ecosystem services, million €[122]

Ecosystem services	Type of the economic unit: Corporations – Agriculture	Corporations – Hunting	Corporations – Electricity, gas, steam and air conditioning supply	Corporations – Human health activities	General government	Households	NPISH	Rest of the world	Ecosystem type: **1.1 Semi-natural grassland**	1.1.1 Semi-natural grassland according to the NATURA classification	1.1.2 Other semi-natural grassland	**1.2 Cultivated grassland**	1.2.1.1 Environmental non-sensitive permanent grassland	1.2.1.2 Environmental sensitive permanent grassland	Intermediate supply from cropland to grassland	TOTAL SUPPLY: **Grassland total**	**Estonia total**
Provisioning																	
Fodder production, rent price									**5,20**	2,09	3,11	**20,79**	20,75	0,04		**25,99**	
Hay for bioenergy									**0,51**	0,51						**0,51**	
Medical herbs									**0,13**	0,05	0,07	**0,07**	0,07	0,00		**0,19**	
Game									**0,56**	0,26	0,29	**0,59**	0,59	0,00		**1,15**	**8,48**
Regulating and maintenance																	
C sequestration (EUA price)									**0,00**			**0,00**		0,16		**0,00**	
Pollination									**3,05**	0,86	2,18	**3,86**	3,85	0,01		**6,91**	**19,25**
Cultural																	
Nature education, cost based									**0,63**	0,28	0,35	**0,12**	0,12	0,00		**0,75**	**8,75**
Hunting, expenditure based									**1,07**	0,47	0,60	**1,15**	1,15	0,00		**2,22**	**16,19**
Recreation									**3,07**	1,37	1,70	**2,24**	2,23	0,01		**5,30**	**51,00**

USE TABLE

Ecosystem services	Type of the economic unit: Corporations – Agriculture	Corporations – Hunting	Corporations – Electricity, gas, steam and air conditioning supply	Corporations – Human health activities	General government	Households	NPISH	Rest of the world	Ecosystem type: **1.1 Semi-natural grassland**	1.1.1 Semi-natural grassland according to the NATURA classification	1.1.2 Other semi-natural grassland	**1.2 Cultivated grassland**	1.2.1.1 Environmental non-sensitive permanent grassland	1.2.1.2 Environmental sensitive permanent grassland	Intermediate supply from cropland to grassland	TOTAL USE: **Grassland**	**Estonia total**
Provisioning																	
Fodder production, rent price	25,99															**25,99**	
Hay for bioenergy			0,51													**0,51**	
Medical herbs				0,19												**0,19**	
Game		1,15														**1,15**	**8,48**
Regulating and maintenance																	
C sequestration (EUA price)						0,00										**0,00**	
Pollination															6,91	**6,91**	**19,25**
Cultural																	
Nature education, real data					0,75											**0,75**	**8,75**
Hunting, expenditure based						2,22										**2,22**	**16,19**
Recreation						5,30										**5,30**	**51,00**

4.2 Integration of the ecosystem service values with national accounts, supply and use tables

Another goal was to integrate the ecosystem service values with national accounts supply and use tables and analyse these in sense of SNA and non-SNA perspective.

Some of the values calculated during the project were already included to national accounts but not considered as ecosystem services, as ecosystem is not traditionally separated as institutional sector that supplies services. Table 59 shows if the ecosystem services values are included in national accounts.

[122] Editing: In the table the intermediate supply should be written „from grassland to cropland“

Table 59. List of SNA and non-SNA ecosystem services in Estonia

Ecosystem services	Already included in SNA
Provisioning	
Fodder production	Yes
Hay for bioenergy	Yes
Medical herbs	Yes
Game	Yes
Regulating and maintenance	
Climate regulation, stock provision	No, TBD
Pollination	No
Cultural	
Nature education, real data	Yes
Hunting, expenditure based	Yes
Recreation, time use	No

Non-SNA values are not included in the national accounts but principally these services do have values and could be considered in monetary terms. Therefore these could be analysed in the context of economic growth that has the impact on everyday lives. In our case, these are primarily regulative ecosystem services but also cultural services.

Integration of supply and use tables shows how ecosystem service flows move from supplier to user. For SNA services integration shows how ecosystems have contributed to value added but does not expand it and rather redistributes already made value added between monetary sectors and ecosystem. Adding non-SNA service values to the supply and use tables would expand also value added as these are not considered in national accounts yet. In some cases it is not so straightforward, as part of the service could be counted in SNA like in case of hunting and game ecosystem services.

Estimating the ecosystem service values gives opportunity to add extra dimension to national accounts tables by possibility to see how ecosystems have contributed to value added that has been produced.

4.2.1 Integration of ecosystem service values with national accounts supply and use tables: example of nature education service

An example about integration of ecosystem service values with national accounts was made for nature education ecosystem service (Table 47, ANNEX 11) and the example of the treatment of all tested nature education value calculation methods are shown in Table 60.

Table 60. The supply and use of nature education service (million €), 2018

	Eco-systems	Corporations						General government			NPISH	Final consumption of households	Total
		A.02	H.49	L.68	M.74_75	P.85	R.93	O.84	P.85	R.90_91	S.94		
1. Expenditure transfer approach													
Supply													**5.12**
Ecosystem service - nature education	5.12												5.12
Use													**5.12**
Ecosystem service - nature education									5.12				5.12
Value added (supply-use)	**5.12**								**5.12**				
2. Expenditure based approach													
Supply													**1.58**
Ecosystem service - nature education	0.27												0.27
Nature education		0.65		0.00	0.00	0.00	0.01	0.03	0.07	0.41	0.13		1.31
Use													**1.58**
Ecosystem service - nature education		0.20		0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.01		0.27
Nature education									1.31				1.31
Value added (supply-use)	**0.27**	**0.45**		**0.00**	**0.00**	**0.00**	**0.01**	**0.03**	**0.06**	**0.37**	**0.12**		**1.31**
3. Travel cost based approach													
Supply													**2.02**
Ecosystem service - nature education	0.30												0.30
Nature education			1.72										1.72
Use													**2.02**
Ecosystem service - nature education			0.30										0.30
Nature education									1.72				1.72
Value added (supply-use)	**0.30**		**1.42**										**1.72**
4. Willingness to pay method													
Supply													**1.27**
Ecosystem service - nature education	1.27												1.27
Use													**1.27**
Ecosystem service - nature education												1.27	1.27
Value added (supply-use)	**1.27**												**1.27**
5. Sum of expenditure based methods													
Supply													**8.72**
Ecosystem service - nature	**8.72**												**8.72**
Use													**8.72**
Ecosystem service - nature education			1.72						7.00				**8.72**
Value added (supply-use)	**8.72**												**8.72**

"Ecosystems" as the providers of the ecosystem services are singled out in left most column and five evaluation methods are shown separately in 5 sections. Under the column "ecosystems" part of industries value added which comes from ecosystems is shown.

First section "Expenditure transfer approach" describes the allocation of the supply values calculated with expenditure transfer approach, where the whole ecosystem service supply is attributed to ecosystems because it was not possible to separate ecosystems and economic sectors. Ecosystem service user is government sector that then provides the service to students. The consumption of households is not included in the integrated table as it needs more data from various studies and it is not covered in SNA. In this method value added does not expand as the used data is already included in

SNA. In principal integrating ecosystem as a separate supplier demands to lessen value added of general government in order to avoid double counting.

Second part “Expenditure based approach” describes the allocation of the values calculated with expenditure based method. Nature education service providers are ecosystems and various economic sectors that belong to different NACE activities. In use part of the table, ecosystem contribution (0.27) is divided between all economic activities that use ecosystem service to provide their services (it was assumed that most of them use 10% and the largest supplier balanced the supply and use). It is because ecosystem contribution does not expand value added but divides already made and accounted value added (1.3) between economic industries (1.03) and ecosystem (0.27). Industries use ecosystem educational service as an input to supply nature education service. As the supply and use of the service is already included in SNA (economic industries supply the service) then the value added cannot be larger. This section shows the part of industries value added which comes from ecosystems (0.27).

Third section “Travel cost based approach” describes the allocation of the values calculated using travel cost based approach where suppliers are ecosystems and transport sector. Users are transport sector that use ecosystem service to provide their service and households. The logic in this section is the same as was in expenditure based method – supply (2.03) and use (2.03) are larger than value added (1.73) because already accounted value added is distributed between ecosystem and transport activity. It is seen that a part of transport sectors value added actually comes from ecosystems (0.30).

Fourth part “Willingness to pay method” describes the allocation of the values calculated with willingness to pay method where suppliers are ecosystems and users are households. In this section also total value added expands (1.27) because the service value calculated (supply 1.27, use 1.27) with willingness to pay method is not accounted in SNA and is an addition to already included values.

Fifth part of the table describes the allocation of the aggregated total of three expenditure based methods.

In case of nature education ecosystem service – various calculation methods were tested and the sum of expenditure based methods was selected. The result is already included in SNA as the methods use data from actually made transactions. The supplier is the ecosystem and users are transport activity and general government. Households are beneficiaries.

4.2.2 Analysis of other ecosystem service values in the context of SNA and non-SNA

Fodder production ecosystem service –Rent price method was selected. The service value was calculated to be 21 million € with the rent price method in 2018. The service is supplied by ecosystems and used by farmers. The value calculated with rent price method is already included in SNA as the land is theoretically paid for. However the share of the ecosystem contribution was not separated.

Biomass from non-agricultural sources - The gross value added (GVA) method was used to calculate the contribution of the ecosystem to the energy sector and it was 156 144 € per year in 2017. This value is considered also in the national accounts as the biomass used for energy production was actually bought as a market good. The service is supplied by ecosystems and used by energy industry. However the share of the ecosystem in contribution was not separated.

Provisioning of game/hunting - The sum of the quantity of hunted big game multiplied by the average quantity of meat obtained from the game species (weight of game carcass) and purchase price of game meat were used to calculate the value of the ecosystem service of providing game. The ecosystem provisioning service value of providing game was 8.5 million €. This value is just partly included in the SNA as all the hunted game was probably not sold. It is difficult to determine the part that was actually traded and is included to the national accounts. The service is supplied by ecosystems and used by hunting industry. However the share of the ecosystem in contribution was not separated.

Provisioning of medicinal herbs – Market price method was used to calculate the ecosystem service value. Based on the calculations, the ecosystem service value of providing medicinal herbs by grassland was 191 034 €. This value can be considered as SNA service, as marketed quantities and market prices were used. The service is provided by ecosystems and used by pharmacology sector. However the share of the ecosystem in contribution was not estimated.

Climate regulation - Payment for ecosystem services (PES) schemes was used to assess the monetary value of the ecosystem service. The total value of the Estonian grassland ecosystem service as a carbon storage was calculated to be approximately 54 million €. This value is non-SNA value as it is not included in the supply and use tables as a service value. Integration of this service value to the national accounts tables would expand the value added and supply and use. The service is supplied by ecosystems and used by all sectors and thus attributed to households. The share of the ecosystems contribution is 100%.

Pollination – Method that based on modelling in order to calculate the avoided cots were selected to evaluate the ecosystem service value. The value is non-SNA value and is not included in SNA yet. The service is provided by ecosystems and used by agricultural activity. The share of the ecosystems contribution is 100%.

Nature recreation – The service value was calculated with time use method and the annual value of the ecosystem recreational service in Estonia was calculated to be 51 million €. This can be considered as non-SNA value and it is not included to the national accounts as the time spent outside does not have an actual monetary flow. The service is supplied by ecosystems and used by households. The share of the ecosystems contribution was not calculated.

Recreational hunting – The value of the service was calculated in two aspects – narrow and wide, which were summed up (in case of non-overlapping part). In the narrow scope the value of the service was calculated on the basis of yearly hunting fees. In the wide scope the value of the service was calculated on the basis of annual average expenditure per person. The value of the service was calculated to be 16.2 million € in 2018. The value is already included in SNA as the hunting fees and expenditures (although calculated on the basis of Germany expenditure structure) are theoretically real transactions.

It can be concluded, regarding the compiled supply and use tables and the differentiation between the SNA and non-SNA benefits that:

- provisioning services are part of the SNA (it is possible to make it explicit in the ecosystem accounts and in that case it should be taken out from core SNA)
- regulatory services are not SNA benefits
- cultural and educational services are a mix of SNA and non-SNA benefits as it is generally also agreed by the UN SEEA experts

Regarding the handling of intermediate and final services in supply and use tables, it was found that the services valued by Statistics Estonia this year, only pollination is an intermediate ecosystem service. It was agreed that pollination should be indicated under “from grassland to cropland” (supplied by grassland to cropland) and in the use table under “ecosystem” (as the service is used by another ecosystem).

Regarding the supply and use tables compilation the consultations were performed with Alessandra La Notte[123] from JRC and the results have been updated in. Consultations with Alessandra helped to identify the user and beneficiary of the services but also how the service flow moves from ecosystems to users.

[123] -personal communication

5. Initial thoughts on the applicability of the ecosystem accounts in Estonia

5.1 Possibilities of the developed ecosystem accounts based on project experts discussions

The main results of the current work: the ecosystem extent account and an experimental valuation of eight selected ecosystem services were made available for the project experts in the late stage of the project. There has not been remarkable feedback from the users but some initial ideas could be outlined.

Ecosystem extent account does provide an insight regarding the owners of the land where important ecosystems are located. Valuation of ecosystem services could highlight the contribution of the ecosystems in the provisioning of ecosystem services. It could also bring into attention the values and valuation approaches of the services not yet in the scope of the SNA as these services do not have a clearly revealed economic value.

Ecosystem profiles, based on provided services will allow for the comparisons across ecosystem types.

5.2 Functional distinction between the types of Estonian grasslands

There are two functional types of Estonian grasslands which need to be distinguished: 1) grasslands which are important for their agricultural production and 2) grassland ecosystems which have high conservation value.

Both, for the compilation of opening extent account and ecosystem services account, the attempt was made to classify the grasslands uniformly depending on their specific features and specific user needs. Two main types were formed: cultivated and semi-natural grasslands.

Semi-natural communities of Estonia (alvars, floodplains, dry and fresh meadows, peat meadows, wooded meadows, coastal meadows, wooded pastures) are one of the most species-rich habitats in the world acknowledged also in the Nature Conservation Development Plan until 2020[124]. Such natural values, however, can be preserved only with human help. Without mowing or grazing, semi-natural grasslands most likely transform to shrubberies and the area might eventually be forested which in turn impacts species diversity negatively. Restoration and maintenance of semi-natural grasslands has been subsidised since 2001.

By 2020, regular maintenance had to be ensured for at least 45 000 ha of semi-natural communities.[125]

5.3 Monitoring the goals of the Nature Conservation Development Plan

Valuation of the ecosystem services provided by grasslands is relevant in Estonia both in the sense of the implementation of the biodiversity strategy and also for the current evaluation of the implementation measures for the conservation of semi-natural grasslands.

[124] Nature Conservation Development Plan until 2020. Ministry of the Environment Tallinn 2012. https://www.cbd.int/doc/world/ee/ee-nbsap-v2-en.pdf
[125] -Ibid.

In addition to the preservation of the management level of already managed semi-natural areas there is a question on the fulfilling a new goal: conservation management of the remaining 15 000 ha of semi-natural grasslands which has to be resolved by 2030 according to the targets set by Nature Conservation Development Plan which was set in 2012.

The management of cultivated grasslands is by its economic content cost effective while the management of semi-natural grasslands is often not cost-effective, this is also referred so in Estonian Rural Development Plan [126], - in a document which outlines the plans on management of semi-natural communities as well.

The investigation of ecosystem services provided by and subsidies paid for semi-natural protected grasslands is important as the financial support for the maintenance (restoration and conservation) of semi-natural grasslands has been significant and has contributed to a remarkable change in respect to the area under management for the period 2001–2018. Possible relevance of ecosystem extent account refer for changes in ownership and changes in land use as for the sustaining of the current level of maintenance of the semi-natural areas and for the reaching the set targets, new additional financial instruments need to be designed.

We hope that ecosystem extent account would facilitate the better analysis of the use and management of the ecosystems. After the compilation of the closing stock in the next phases of the development of the work, the annual change in different dimensions of extent account would become available. This will provide the changes in ownership of land and simultaneously the changes in land use. The latter is associated with the changes in related ecosystems. As land owners are generally not motivated in managing of their semi-natural habitats on their own expenses (i.e. without subsidies) the more advanced analysis of effects of financial instruments and regulatory framework is needed. Hopefully more relevant and more effective measures could be developed by linking the information available in registers and in national accounts on subsidies received and taxes paid with both categories (ecosystem types and land ownership) in the developed extent account.

As mentioned above, the extent account provides the possibility to monitor the change in ownership: it is also important to see, which economic sectors and which kind of owners are responsible for the management of valuable ecosystems contributing to the provisioning of the basket of market and non-market ecosystem service flows. From the viewpoint of the design of the instruments, it might be particularly vital to understand what is the potential volume and heterogeneity of the service flow in case of each ecosystem of interest.

Designers of the instruments have lacked the monitoring land ownership patterns based on continuous series of data and had to base the design of the instruments on single analytical studies and on rather scattered statistics. More evidence would be available if data of various registers will be linked.

Now, one of the results of current work under this grant is that the ownership dimension has become available linking ecosystem units with the owner categories in sense of economic activities and institutional sectors.

[126] - Estonian Rural Development Plan - https://www.agri.ee/en/objectives-activities/estonian-rural-development-plan-erdp-2014-2020

5.4 Services and subsidies of semi-natural grasslands

The investigation of ecosystem services provided by and subsidies paid for semi-natural protected grasslands are important as the financial support for the preservation (restoration and conservation) of semi-natural grasslands has been noteworthy and has contributed to a remarkable change in respect to the area under management in the period 2001–2018.

The subsidies for maintenance of semi-natural areas reached 4.6 million € in 2018 and the services provided in total for the maintenance of the semi-natural grasslands amounted to approximately 5.4 million €, considering measured eight services. Although the total volume of subsidies is similar to the indicated value of the selected services, currently the scope is not exactly the same. The referred 4.6 million € subsidies which were used in 2018 were targeted to the improvement of the quality of care for semi-natural habitats, including the increasing of the share of semi-natural habitats managed by farm cattle, to improve the status of species associated with semi-natural habitats, to increase the area to be maintained and for preserving and enhancing biodiversity and landscape diversity.

However the biggest share of the 5.4 million of the given selected ecosystem services of semi-natural grasslands is the fodder production (2.1 millions). Recreation contributes next biggest share.

Support rates start from 85 € per hectare of mowing a meadow and reaching 450 € per hectare when mowing a wooded meadow. Support rates for grazing a meadow start from 150 € per hectare and reach 250 € per hectare per year for grazing woodland meadows.

When to compare the support rates and the hectare factors of selected ecosystem services it could be said that the average ecosystem service values selected service ha factors are in range of 40-150 € per hectare in average. The analysis of the support rates and provided services could be carried out in future and this work was not foreseen in current study. It is also obligatory to point out again that the selection of the service is far from being complete and that the detected monetary value of ecosystem services is not the total economic value.

As discussed above, cultivated and semi-natural grasslands differ in their profile of the ecosystem service provision. Cultivated and semi-natural grasslands should be looked separately as cultivated grasslands are *a priori* used for the production purposes being a subject for the surplus generation for corporations and taxes for government.

5.5 Support for the design of the financial instruments and management plans for semi-natural communities

Semi-natural grasslands are of high biological value. In determining subsidies, it is important that they ensure the maintenance of the subsidized ecosystems. Better knowledge of the potential and promising ecosystem services flows would be important in order to provide general and specific knowledge for policy development but also for counselling of landowners to stimulate their interest in the management of semi-natural communities.

As the preservation of semi-natural habitats can be enhanced also by using these areas for tourism and recreation purposes the capturing of currently only partially captured flows of the cultural services will be important.

Regulative services are more and more important as the knowledge on the biophysical processes is improving and the role of the specific ecosystem services in maintaining the important functions of the ecosystems have become more acknowledged: flood protection, climate control, pollination, habitat provision etc.

Ecosystem service values, which are competing with each other (for example fodder production versus pollination) will get more and more attention and there is a need to provide more evidence based information both in biophysical and monetary units. Ecosystem accounts could provide valuable inputs in this regard.

5.6 Applicability of ecosystem accounts in modelling of the negative environmental impact and externalities

The data collected and presented in this work could be used to allow the analysis of alternative use of different types of grasslands. The results obtained can be used to make decisions on the use of grassland ecosystems and to prevent ecosystems use decisions that reduce the well-being and the degradation of the environment. For example in our case study if the value of the eight services provided by other semi-natural grasslands (1.1.2.) is 59 € per hectare per year. It would only be economically profitable to the owner of the land to convert the grassland into arable land if the arable land produces more than 59 €/ha/year. In this case, the external costs would be internalized and welfare of society is increased (given eight services considered). Another example is the use of pesticides to increase hay production in semi-natural grasslands.

In summary, the data obtained can be used to decide on alternative grassland uses in the viewpoint to increasing the well-being of society but the coverage of the services is limited in our case study.

5.7 Provision of information on important non SNA ecosystem services not covered in accounts yet

As long as we do not have at least some kind of the value (or range for a value) for the important non SNA ecosystem services (not traded on markets) the decision makers who are responsible for the developing of the instruments for the maintaining the ecosystems services, do not have the structured facts and arguments for designing of the financial instruments and regulatory space which would take into account the ecosystems and their services. We keep in mind the instruments which should ensure the management of sufficient ecosystems of pollinators, carbon binding capacity, enough suitable space for wild game species to find the habitats, to ensure the management of the places were the nature education is provided (for example regarding the valuable ecosystem types) and that the ecosystem processes are maintained.

5.8 Integration of the future user needs

Not all services are equally important. User dialogue was carried out while selection of the services was made in order to cover the important services. The user of the ecosystem services accounts need also the guidelines on which components of the account can be considered for the different needs and how ecosystem services account can be used in policy.

Regarding the presentation of the accounts, it seems relevant for a lot of users that the monetary accounts need to be presented side by side with physical accounts so that monetary accounts would be supplementary with physical accounts (or vice versa).

Good and relevant coverage of the services asks for a cooperation and dialogue. In the context of current work, it is clear that the value itself and the relative difference of semi-natural and cultivated grassland services depends on the selection of eight selected services and also the data and methods used to calculate them. Adding other regulatory services would bring in missing components and more balance to the spectrum of the services.

6. Visualization of the results of the ecosystem accounts in Estonia

The ecosystem unit base map can be regarded as the visualization of the opening ecosystem extent account. Different colours represent different ecosystem types on the map based on LULUCF classification system (Figure 1). Changes in ecosystem extent between different years can be visualized on an interactive donut share chart in future.

Visualisation of the results, regarding the provisioning and use of the ecosystem services was analysed. Taking into account the relatively short duration of the project, it was agreed that the visualisation of the results was not the outmost priority and only the maps illustrating the supply of ecosystem services were produced this year. The ecosystem service provisioning areas of ecosystem services about Estonian grasslands are represented on the illustrative maps under respective service subsections in chapter 3.3. Maps could also be created for the total ha-value of the bundle of selected ecosystem services. The map showing the total ha-values of aggregated ecosystem services is displayed in chapter 3.5.3.

Steps to develop the visualisation solutions for results further will be taken in next stages of the development of the ecosystem extent account in the future. It is also planned to develop an interactive web map of ecosystem extent and ecosystem services (supply and use).

It should be noted that not all spatial data used is publically available, therefore in case of illustrating results, some kind of aggregation should be done. Depending on user demands, one option for this, would be using some grid cell system with relatively large grid size. This kind of approach would help to both illustrate the results of our work as well protecting sensitive data (like land owners or otherwise publically not available data).

7. Problems encountered and questions raised

Current work in developing ecosystem extent and services account, was experimental in nature. During the work a number of issues were raised out of which not all can be answered. In general, the problems could be divided into two. First are the general issues, which are related to conceptual issues, measurement of boundaries, applicability and meaning of the developed accounts. Secondly, there are problems which are specific to services: availability of the data, selection of the methods for monetary valuation, agreement on the methods.

Present chapter outlines several issues encountered and references to the respective chapters.

Problems encountered:

1. As there is a shift in paradigm when ecosystem services are considered both in environmental policy and also in wider context of national accounts, the process of compiling and assembling ecosystem accounts takes time and co-operation. The agreement on the share of responsibilities and services covered and measured country wide could still take time and resources.
2. The meaning and the use of ecosystem services accounts in physical terms is not yet well developed on national scale, so the development of the monetary accounts could in one hand be early but in another hand it would trigger the development of physical ecosystem services account as is a case in Estonia (chapter 5).
3. Regarding institutional capacity and setup: calculating the monetary value of ecosystem services requires close cooperation between different institutions (Statistics Estonia, Environmental Agency, Environmental Board, universities, research institutes etc.) and this cooperation comprises the activities from planning to data exchange towards using accounts data for various policy scenarios and impact analysis.
4. For the purpose of this study, it was initially assumed that a lot of the required biophysical data would be obtained from the ELME project team. However, during the year of implementation of ELME project, the scientific and administrative procedures have not yet been completed and therefore standardized quality data on biophysical values of ecosystem services has not become available.
5. Specific standards and guidelines for compiling ecosystem account are still missing or are not mature or straightforward enough. For example, regarding general guidelines, there is quite often no specific guidelines for the treatment of the accounts in supply and use tables or the criteria for the methods to prefer for valuation purposes (chapter 4). Regarding service specific guidelines for example the assessment of pollination service turned out to be more time and work consuming due to guidelines being too general (chapter 3.3.6).
6. In this work, variety of methods have been used to assess the monetary value of ecosystem services. Some of them were classical methodologies (contingent valuation method, market price method), others were developed during this study taking into account the need to calculate the monetary value under conditions of limited availability of source data and no agreed valuation methodologies. Environmental economists who are the members of the project team are of the opinion that results, obtained by using limited initial data, need further validation.
7. When the results of the valuations depend greatly on an evaluation method selected (chapter 3.3), then how to decide with which valuation method the results reflect ecosystem services

more accurately and closer to objective reality. Example: the value of the grassland fodder production service obtained by the rent method differs from the values obtained by other methods by an order of magnitude for this service: total value of € 25 million versus € 2 million for the hybrid method. The change of the method when calculating the value of fodder supply service will have a profound effect on the total values per hectare and at the same time, the values of individual services (chapter 3.5.1).

8. What to do with the results obtained by alternative methods (chapter 3.5.1) in the context of political debates? There is a risk that the application of different valuation methods, which give (greatly) different results, will hinder the comparability and trust in the figures which are meant to describe the relative contribution of specific ecosystem types to the provisioning of interested services. For example, the profile of Northern alluvial meadows is completely different when looking at the results calculated by different methods. Regarding choosing between different valuation methods, there is still space for improvement and there remains a certain degree of scepticism when counting the whole rent price or expenditure as ecosystem service.
9. Which part of the value of the calculated service values could or should be attributed to the ecosystem and how to calculate it (described in chapter 4)?
10. Environmental accountants and environmental economists speak a different language (despite the fact that the underlying concepts may be exactly the same): scientific and statistical methods, semantics and understanding of the valuation differ. Accountants think in the frames of SNA. However, environmental economists focus on monetary valuation of the contribution of natural capital on welfare (consumer surplus method application). One of such method is contingent valuation method (CVM). The results derived by CVM method were analysed and discussed from both statistical and accounting point of view during the grant work. The disadvantage of the results obtained by CVM method lies in the fact, that although the results reflect the real ability of quantified non-market values to positively influence the well-being of individuals, the identified monetary equivalent using CVM is not based on actual expenditure and therefore on actual turnover. This fact makes the usability of monetary equivalent of the ecosystem services found by the CVM method problematic in statistics (chapter 3.4.3).
11. Valuation guidelines are still quite general when the exchange prices are not available. The description of specific problems and challenges are discussed separately under each service valuation (chapter 3.3)
12. Current concept of the ecosystem accounting does not allow clear valuation and allocation of biodiversity service. The value of biodiversity, which have been handled as a value of habitat provision is considered by several experts to be an “intermediate service” but it does not need to be considered as such. It was discussed that biodiversity service could be expressed also as cultural psychosocial service. According to the opinion of some project experts, the value of biodiversity is by its very nature a final ecosystem service that directly contributes to the human well-being. After all, high biodiversity is the main reason why semi-natural grasslands are often protected and paid for (preserved). For example preserving the biodiversity (in this work, the habitat service) is the most important reasons for subsidizing semi-natural grasslands maintenance and management. Habitat service value is a prerequisite for but is not identical with, the value of biodiversity. How to assess the value of biodiversity is a separate issue, but according to the opinion of some experts it is clear, that the exclusion of this service value reduces the value of semi-natural habitats as a provider of ecosystem services. The maintenance and management of semi-natural grassland, paid in the form of subsidies, is covered by 4.6

million € per year but is not covered in the range of the ecosystem services capture due to the above mentioned conceptual issues (chapter 3.3.10).

13. If biophysical modelling has not been carried out by other dedicated national institutions (Institutes, Universities, and Environmental Agency) due to technical requirements and large amounts of data, then the monetary valuation of some ecosystem services can become problematic. In current study pollination ecosystem service was a service for which full biophysical modelling was desired but despite applying the instructions available and suggestions given could not be carried out due to technical capacity and available time. Therefore, an alternative methodology which was less resource demanding was applied. In view of the current progress, the calculations of pollination service will probably be repeated by both methods in the next period of the development of ecosystem accounts (chapter 3.3.6).
14. Do we need to aggregate various service values over ecosystem types or over the groups of ecosystems? If yes, then is the monetary values a right way to perform the aggregation (chapters 3.5.2 and chapter 5)?
15. Even though the dimension of the owners of the ecosystems in ecosystem extent account was created, it provides us with partial information relevant to the condition of the ecosystems and their services. The actual user and operator of the land and ecosystems could be another economic actor. The ownership information is available from the registries, but the information about the actual users is not yet readily available. From the viewpoint of the design of environmental and also agricultural or other policy instruments or policy measures, the information about the operators (managers) and their practices would be of importance.
16. How to take into account the condition of the ecosystem in the provisioning of the services?

8. Way forward in Estonia

Relying on the experience gained during this grant work in developing ecosystem accounts, there are some guidance points collected to base our work while continuing the development of ecosystem accounts:

1. The scope of the grant next year (2020-2021) will be widened to include other ecosystems as well. Based on one ecosystem type (grasslands) it is too early to make general conclusions regarding the compilation of ecosystem accounts.
2. More regulative services need to be covered in next phases of the development of ecosystem accounts in order to reach higher practical usability. However, assessing regulative services needs detailed background data and biophysical modelling.
3. Continuation of the started work of Statistics Estonia on the valuation of cultural services, was suggested by the UN SEEA EEA revisers. It has been considered a challenging area and the efforts of Statistics Estonia to work through the issues have been considered important from a statistical and accounting perspective. The definition and framing of the services, development of the methodologies for measurement, having a consistent approach across different cultural services - potentially applying the Fish model - could be useful. Thus, seeing how the Fish model[127] is currently applied for nature education service could be a direction to go forward for other cultural ecosystem services as well (chapter 3.3.9).
4. The compilation of a condition account is considered important. Condition (quality) aspects of nature education proving ecosystems were not considered when the spatial allocation of the service value was performed. Currently there are no known agreed criteria to be applied. The criteria relevant to specific ecosystem features to support nature education activity, such as learning infrastructure, rarity, representativeness, diversity, provisioning of the scientific knowledge, ability to reflect ecosystem process were determined in the current grant. Still, the quality parameters of the site were not included in calculations as it takes time and effort to obtain relevant spatial information and integrate this in our spatially informed database. Only the ecological integrity was considered in the phase of creating polygons (all partially intersected ecosystems were included to the polygons), as the ecological stability is important in maintaining the continuing capacity of the ecosystem to supply nature education services. Data of Natura 2000 protected areas network and data of protected areas which are outside of Natura 2000 network to represent condition for services assessment could be added in first order in future (Chapter 3.3.9.14).
5. To consider the ecosystems assets is also important as the assets underpin the flow of the provided services in addition to condition as described above.
6. There is still quite a way to go in order to determine the contribution of ecosystems in provisioning ecosystem services and developing relevant semantics in order to set the calculated figures in a wider context of the policy debate on conservation and maintenance of ecosystem assets and services (3.3.9).

[127] Fish, R., Church, A., Winter, M., 2016 Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. Ecosystem Services, Volume 21, Part B, 2016, Pages 208-217, ISSN 2212-0416, https://doi.org/10.1016/j.ecoser.2016.09.002

7. Regarding the presentation of the accounts it seems relevant to maintain the linkage between monetary and biophysical values of ecosystem services for better understanding of the figures and for that it is best to present monetary accounts side by side with physical accounts.
8. The analysis of the feasibility to derive the information on the users (not just the owners) of the land (and hence the related ecosystems) in ecosystem extent account should be taken further in order to increase the practicality of the ecosystem accounts.
9. Stated preferences methods (CVM – contingent valuation method) will be applied for monetary assessment of additional ecosystem services that accrue when more ecosystem types are analysed.

9. Conclusions

Current project was an accomplishment as during quite a short time (one year) the explicit ecosystem unit map was created, opening ecosystem extent account by owners sector and activity categories was created, eight ecosystem services were selected and monetary valuations were tried out regarding the different grassland types in Estonia. In addition, on the basis of ecosystem services the experimental supply and use tables were created. One ecosystem service, namely nature education ecosystem service, was analysed in depth.

This project was the first attempt to develop ecosystems accounts in Statistics Estonia. The grant work was carried out as two connected tasks. Two steps taken by Statistics Estonia in applying UN SEEA EEA principles for the valuation of ecosystem services were:

1. Compilation of land accounts which are relevant for ecosystem extent account and handling of the classification issues (chapter 2)
2. Valuation of grassland ecosystem services, compilation of the supply and use tables and the analysis of the results (chapters 3-7)

The work was planned and carried out in cooperation with other activities on the subject currently taking place in Estonia

ANNEX 1. Study visit conclusions "Development of the ecosystem extent account and valuation of grassland ecosystem services“. May 27-29, 2019

Abbreviations:
SE – Statistics Estonia
NL – Statistics Netherlands

Kaia Oras (SE): Introduction and overview of Estonian ecosystem accounts and update of the progress so far.

1. Ecosystem extent

1.1 Introducrion and overview

Kaia gave an overview on ecosystem extent compilation. SE has collected all relevant and up to date spatial data concerning Estonia’s ecosystems, compiled spatially explicit base map for example study area, started to create the link between land owners and „ecosystems“ for example study area.

Regarding grassland services valuation SE has made the selection of services to be valuated considering importance, data availability, applicability of calculations and recommendations/interest of potential users.

Potential data sources and calculation methods have been analysed. SE has had two meetings with Estonian stakeholders, two SKYPE meetings with Dutch experts, one telecom with UK statistics. There have been several separate meetings with Estonia’s experts for the discussion of services and co-ordination meetings with MAES team. SE has agreed the services with our users for now. SE has screened the methods. Priority services considered for valuation in 2019 are provisioning (fodder, medical herbs, raw material for bioenergy, wild berries and mushrooms (also game and fish)), regulating (pollination, C sequestration), cultural (tourism and recreation, environmental education).

Some calculations have been tested. CVM method is under analyses.

Comment (NL): Including contingent valuation (willingness to pay approach) seems a good idea, as it is giving additional layer of information compared to exchange values and gives opportunity to compare the results.

Kaia gave an overview how the work on ecosystem accounting is advancing in Estonia and classification issues across the ecosystems. Evaluation of ecosystem services in physical terms has been planned as a joint effort with a project currently under way in Estonia and led by Estonian MAES (Mapping and Assessment of Ecosystem Services) team and respective project ELME currently under way involving Environmental and Financial Ministries. Timing of an efforts is different and also the scope of the action. If MAES/ELME teams map/evaluate four ecosystems and the extent plus potential supply, SE focuses on actual supply and on the extent of all ecosystems.

Comment (NL): also different groups are working here in Netherlands on ecosystem services, in general, the classification of the ecosystems is a real issue, especially for transition areas. There is no one and only ecosystem classification scheme at the moment that could be used uniformly everywhere, like USGS classification is itself very comprehensive but lacks real ecology.

Kaia described that existing national and international classifications for ecosystem and land use are analysed and the best options in the sense of detail and comparability will be chosen depending on the quality of the underlying data structures. There is no a full classification of ecosystems in Estonia. We have land use classification and the habitats classifications (separate for grasslands, forests, wetlands etc.). In Estonia, we plan to apply Estonian local classification as well EUNIS habitat classification in order to classify the spatial units. We are also thinking about LULUCF classification.

Comment (NL): Good idea. Regarding LULUCF, NL not so familiar with LULUCF classification for ecosystem types.

1.2. Overview on the creation of the ecosystem extent account (presentation by Argo Ronk, SE)

Example study area was used as prototype. Data Sources were described and the order of priorities, from newest to oldest: 1. Agricultural land and semi-natural communities (support bases), 2. Forests, 3. Wetlands, 4. Semi-natural communities (Eligible for support), 5. Natura 2000 habitats inventory, 6.Meadows database, 7. Estonian Topographic Database.

The merged dataset was described. At the moment SE has original classification: 103 different types. Types are the mix of different habitats, land-use and land cover classes. These classes cover 100% of Estonia's terrestrial area (incl. inland waters). We plan to use Estonia's own national classification system, i.e "Classification of habitat types of Estonian vegetation". This would exclude roads, urban areas. In addition SE builds a link to EUNIS habitat classification. This would cover 100% of Estonia's terrestrial area.

In addition we plan to create a link to UNFCCC/IPCC land use classes (LULUCF).

1.3. Discussion points

Argo: Marine areas are excluded in our ecosystem accounting area in Estonia.

Argo: Potential problems: Only field parcels/areas that receive support are precisely mapped. So the agricultural areas which do not claim subsidies, for example crop production (although crop production could be high). In this case we do not have more detailed information about this area, besides knowing it is just an agricultural area (this low level information comes from Estonian topographic database). Around 80-90%.agricultural land there in Estonia receives some kind of subsidies.

Argo: Regarding Forest Register, most of the data are within ten 10 years' time frame but some data are even older. Potential problems: clearcut areas not recorded in the map (outdated registry). There are unmapped areas (75-80% of forests are mapped).

Patrick: Would it be possible to use remote sensing for Estonian forests for example to determine unmapped and clear-cut areas. Answer: This is something that local MAES people are actually doing but we don't see it in our project right now, at least not in this year.

Argo: Wetlands data contain areas with multiple classifications (for example transitional areas) are problem and one needs somewhat prioritize which kind of classification type to use (this could be issue to discuss with local stakeholders), as in ecosystem accounting, the ecosystems themselves, have to be mutually exclusive in order to avoid double counting.

Argo: The issue with potentially outdated datasets creates new problem, that the ecosystem which was present there at the time of recording (e.g., 15-20 years ago), may have completely changed to other ecosystem type. For example grassland has turned into forest due to non-use of grassland. This is an issue that is not easy to solve but from accounting perspective one should use the most recent data that is available. Therefore, if there is more recent information that the area that used to be grassland is now considered as forest, one should treat it as forest, as this is the most recent knowledge we have for this area.

Issues remain with the areas, where only Estonian topographic database information is available, due to latter using very broad classes/types to define the spatial units (e.g. forest, agricultural land, wetland etc.). Maybe one solution would be to try to understand that why more detailed information is missing from these areas and from there maybe you could reach to possible solutions.

Sjoerd: In case of dealing with ownerships (owners of the ecosystems), there can be a legal owner (e.g., the Bank) and economic owner (e.g., farmer who is using the land), the latter is more important, as they are mainly the beneficiaries of ecosystem services. In case of Estonia the information about economic owners are largely unavailable.

Patrick: How detailed classification level do you plan to use in case of EUNIS.

Answer, Argo: Currently we do not know yet, probably we do as much as is feasible, nevertheless, it would make sense to aim most detailed level possible, as you can aggregate later more easily than disaggregate.

1.4. Overview of Netherland systems of ecosystem extent account, classification of ecosystems and using of spatial data (presentation by Patrick Boogart, NL)

Extent maps for 2006 and 2013. Construction steps: 1. Water vs Land (BRT); 2.Agricultural (BRP) /Paved / Unpaved; 3.Paved: (1. Residential (Addresses & buildings); >2ha; 25%, 2. Businesses (+ NACE); 3. Greenhouses (topomap), 4. Infrastructure (topomap), 5. Other) 4. Unpaved: Agri; Nature; 5. 'Functional' units (floodplains; dunes; salt marshes). NL mostly agricultural; some pockets of forest, heathland and wetlands.

Changes in ecosystem extent for the main ecosystem types between Ecosystem Type maps of 2006 and 2013. Tabel. Can be visualized on map or graphs (interactive donut share chart).

The IUCN RLE classification is recently developed by IUCN, it complies with all design criteria, explicit theoretical foundation and takes ecosystem as its conceptual base, strong biological component. Testing of the applicability of the system (can it be mapped covering total area of Estonia, linked to existing local classification systems) should be done in 2019 to include it into SEEA revised manual.

NL Base Map Nature commissioned by the NL Environmental Assessment Agency for policy making regarding nature. Mapping issues: 1. Rasterization (streams; linear features, 2. Definitions (LuLuCF != FAO != Top10NL); 3. Unclear status of 'unofficial' nature areas.

It is better to get bigger assets and then the asset attributes characterize the distribution, e.g 59% agricultural, 30% grassland, 11% forest, 10 metres of hedgerows

1.5. Discussion of the ecosystem extent account: classification issues in general and in Estonia according to five points raised by Estonia

SE: Ecosystem classification issues: from land use and land cover to ecosystems. Which steps need to be taken to get from land use and cover classification to ecosystems based classification? Possibility to switch classifications (availability of the "translation tables" between different classifications). Use of national and regional classifications, which one should be preferred? Could you provide an example using Dutch national data?

NL:

There is no good answer, how to go beyond land use and land cover classification to ecosystems types, at least not yet. Most of the countries are facing the same challenges.

There is also MAES ecosystem classification, but this classification uses very broad classes and actually mixes both ecosystems with land cover classes.

Ecosystem classification may well also depend on the need of the users, if broad classes (like land cover/use) satisfy the potential users, it may well be efficient enough then to use those. But of course this kind of classification also influence the quality of ecosystem services these provide. Therefore, the goal should be to classify different ecosystems types as detailed as the data allows.

SE: Ecosystem type classification for SEEA EEA: ways of handling the national data.

NL: Five proposals handled in document for revision of UN SEEA EEA were discussed. Patrick presented the state of the art of the proposals considered in document for revision of UN SEEA. Key revision issue for SEEA EEA is to develop a proposal for a reference classification that better represents the concept and coverage of ecosystems. It must be scientifically credible, salient and legitimate for policy framework. In addition, the classification typology should represent ecosystems, classification units should be spatially delineated, geographically and conceptually exhaustive, and comprehensive across all environmental domains, classification types are mutually exclusive, classification should be practicable and linkable to other established classification systems.Options for a (high level) reference classification scheme: 1. IUCN Red List of Ecosystems; 2. USGS/Esri GDBBS; 3. A two-tier approach building upon and linking IUCN RLE and USGS/Esri GDBBS; 4. Existing habitat classifications (e.g. IUCN, EUNIS); 5. Existing land cover classifications (e.g. FAO, Corine). The first three are the recommended options due to their conceptual relevance and depth and their coverage of all relevant environmental domains.

SE: Visualization of the results. How should the results be displayed using spatial data?

NL: One should be aware that not all used data is not publically available for example land owners, therefore in case of displaying results, some kind of aggregation should be done in way one could not pinpoint the actual owner. One option to achieve this, is to use grid cell system with broad resolution and map the proportions.

SE: Application of the results of the ecosystem extent accounts. Dimension of the owners of the ecosystems and users of the ecosystems services. How did you create the link to the owners and especially users? How to make the best use of the generated information? Is there a real value added if exploring the dimension of the owners?

NL: In case of looking ecosystems ownership by economic activity point of view would not probably be very informative in the sense of ecosystems accounting, as for example every forest is allocated to forestry activity (or one piece of area is owned by electric company or chemical company. In Netherlands, ownership approach was not pursued.

SE: Using spatial data and performing spatial data analyses for calculating provisioning, regulating and cultural services (physical and monetary valuation, potential and actual supply). How spatial are Dutch ecosystem services accounts (physical and monetary, coverage of the services)?
NL: Approach is spatial. Issue is described under separate services.

2. Role of Statistics Netherlands in ecosystem accounting

Consortium of Stats Office (~2/3 work) and Wageningen University (~1/3 work). Wageningen University focuses on (spatial) modelling of ecosystem services. Stats Office work on extent account and valuation of most of the services.
Ecosystem accounting team belongs to the National Accounting department in NL.
Data for the accounts are not gathered only within Statistics Netherlands, but come from many other sources, like institutes, and that brings some issues: sharing the data, detail of the data, time series.

3. Ecosystem services valuation in Estonia

Kaia Oras gave an overview of work done on ecosystem services valuation in Estonia so far: researching ecosystem services monetary valuation methods, meeting with experts and prioritization of the demand of ecosystem services valuation according to users. Discussion of the methods for the estimation of the services in physical and monetary terms (NL and ES experience)

3.1.Overview of NL work on biophysical ecosystem services accounts

Services valued in biophysical terms in NL work: Crop production, Fodder production, Timber production, Biomass from non-agricultural sources. Air filtration, Carbon sequestration in biomass, Pollination, Water filtration, Natural pest control, Erosion prevention, Protection against heavy rainfall. Nature recreation (hiking), Nature tourism, Amenity service (monetary).
Supply in providing ecosystem services is spatial for all the services.
Biophysical ecosystem service use account:
First know the supply and then determine the users. How to allocate the users? The benefits of the services that have economic use go to the economic owner (sector), non-SNA (regulative) go to all population. Export sector in use table represents rest of the world (tourism e.g), in monetary use table - government sector. Environmental (global goods) column is under discussion, could be the same as government sector.
Visualization: use table of services by sectors, table of relative supply in providing services per regions (good for comparisons).
Methods:
Top-down: available national/provincial/local statistics and then you have to connect them to the spatial data of the services provided (often based on ecosystem map, sometimes more detailed maps).

Bottom-up: look-up tables from scientific research and then you have to connect them to the spatial data of the services provided (often based on ecosystem map, sometimes more detailed maps).

3.2. Overview of NL work on monetary ecosystem services accounts

Ecosystem services supply and use account, ecosystem monetary asset account and integration into system of national account is the objective of the project in the Netherlands. Monetary accounts are almost finished, soon to be published. The aim is to provide experimental monetary values for ecosystem services, contribution of ecosystem to certain services, not present the true value of nature.

3.2.1. Values

Focus on economic values, value actual use of final ecosystem services, methods consistent with SNA. Manual allows to experiment also with welfare values, not only exchange values.

It is important to identify asset (i.e ecosystem type), service, benefits and beneficiaries to make things clearer.

In SEEA EEA approach focus is only on part of the total economic value of nature that is actual/planned use.

Intrinsic value- value with no anthropogenic influence in it, nature as a value in itself.

Option value – nature is available and could provide ecosystem service, only that you do not actually use it or plan to use it, potential supply.

Non-use value – when you have to maintain a sustainable part of ET, e.g bequest value leaving nature area for next generation.

3.2.2. Asset and production boundary

Asset in SEEA means you look at all different ET represented by assets even if it does not have an owner or direct economic value, which is what SNA defines it by. Assets do not have monetary value in SNA but services do and trough ecosystem services asset gets a value (e.g mussel bank produces mussels) - asset boundary and production boundary working together. It is not enough to extend only asset boundary because assets do not have a value. If you extend the production boundary defined by SNA to SEEA, asset is linked to owner and producer and then can provide extra value added and therefore also increase GDP.

What kind of assets are considered assets in national accounts? Land, natural resources, growing forest. According to SEEA forest where timber is not used should be included as an asset, according to SNA not included.

There are a paragraph in NL report and section on SEEA CF on production in the asset boundary for further reading on the topic.

3.2.3. Approaches

Exchange values is the recommended approach in the SEEA EEA. It is important to distinguish exchange values that are incorporated in GDP from those that are not when integrating the values to SNA. Welfare values include consumer surplus are not consistent with SNA but nevertheless are valuable for determining and comparing exchange values. GVA/NVA (gross/net value added) approach looks at the industries that are directly dependent on natural capital and what is their value added. Simple method, shows which industries (forestry, agriculture, recreation) are dependent on natural capital and their contribution to GDP, also a measure of nature's contribution to economy. At what level to stop looking at GVA, the higher the level, the higher the value, e.g farmer vs cheese producer. In GVA approach do not deduct labour costs and other human input like for exchange values. GVA approach is suitable for valuing provisioning services.

3.2.4. Methods

Different valuation methods produce different types of values and are suitable for different ecosystem services. When using two or more methods to value an ecosystem service, the methods may look at different aspects of the service, but cannot add them up because there is a risk of double counting. Test different methods and argue which results reflect the value of the service the best.

End result is the supply and use tables (NL 10 services valued in monetary units), compilation of which is same as for biophysical SUTs. This does not consider benefits, but ET contribution to benefits, to value benefits, GVA approach could be used to interpret benefits.

3.2.5. Asset values:

Asset valued by net present value approach (convert the estimated flow of ecosystem services into an estimate of the associated asset value) described in SEEA. There is a formula with some assumptions. Discount rate is important as it influences the result greatly, NL got the value of 3% from the report of their environmental agency. Asset life 100 years (Rocky suggests also), can also say it is indefinite time period, has not much influence on overall results. NL promised to send SE formula for asset value calculations (example made for timber).

Asset account: asset values allocated for one year. Asset value is mostly influenced by services, their valuation methods and also the assumptions. For NL recreation service has the biggest input to asset values as the demand and therefore also supply is the highest for it, regulating services have low values.

3.3. Services (NL biophysical valuation, SE work on monetary valuation with NL comments)

3.3.1. Fodder

Two biophysical valuation methods (NL): harvest projections combined with the parcel registry and distribution of net primary productivity (NPP). Results of the two methods were different. To improve results, second approach was used to re-allocate mean harvest projections.

In this case no distinction was made between economic and ecosystem input, total amount of fodder coming from field was used for calculations. Very difficult to locate inputs like soil water, nutrients, in KIP INCA, SEEA reports methods to tackle it. In physical sense total harvest as proxy for ecosystem service is OK. Grass eaten by cattle is already included in harvest projections.

Comment (SE): SE don't calculate fodder in physical units, for monetary SE has harvest data.

Answer: Don't need conversion of the total to the fiscal, maps can be done for monetary valuations independently.

Monetary valuation (SE)

Rent price method – SE has average rent prices by Estonian counties from agricultural statistics and hectares from the extent account. SE multiplied the price with hectares and got the value of grasslands by Estonian counties.
Resource rent method – SE used the resource rent formula but the return to produced assets is missing.
Question (SE): Where could SE get the return to produced assets, SE national accounts team did not have it?
Answer: In NL return to produced assets variable is calculated for using in production accounts, NA team has their own methodology for it. In principal if you have the capital account, you can from total produced capital by industries calculate consumption of capital services or calculate return of capital according to formula in the manual of SNA or OECD guide on capital production account. Sjoerd promised to help us with that problem and send the formula.
Question (SE): Probably big part of the rent information is not known. How can SE find the rent prices of the land? SE has average rent prices for agricultural areas by counties.
Answer: In NL also only a part of the agricultural land is leased but the method was deemed good and the average price was applied to all of the land. Depends whether the average rent price is a good representative of the rent prices.
Question (SE): Should SE make different calculations and consider differently if the fodder is eaten by livestock directly in the grassland and if the fodder is first collected and then feed to animals that are kept inside?
Answer: In monetary terms it does not make any difference.

3.3.2. Biomass from non-agricultural sources (Raw materials, biomass for bioenergy)

Biophysical valuation method (NL): NPP carbon uptake (similar to fodder) on natural grasslands and other unpaved terrain (roadsides). This value represents potential supply.
Monetary valuation (SE): SE has the amount and monetary value of the raw material (grass) that was bought to be burnt in boiler station to produce heat from energy statistics. We also have the amount of produced heat and its price. No spatial data of real supply available.
Question (SE): Should we use the purchase price of raw material or selling price of produced heat in the service valuation?
Answer: Using the amount/price of biomass to produce bioenergy would be a good approach. Resource rent method would be difficult to do on energy sector where energy companies use mainly fossil fuels.
Question (SE): Is it right approach to use the market price of heat (enterprise income) and deduct intermediate costs of the enterprise (costs for goods, material, services and labour costs and other financial costs) from it (data from annual financial report)? Which costs should be deducted?
Answer: If you look at the benefit, you have to deduct intermediate costs, such as labour costs, other costs. If you have the price of the grass, it would still be the best proxy, no need to deduct costs from that. Option for additional information is to look at the gross value added if the companies are directly dependent on the ecosystem service.
Comment (Kaia): check with PKÜ if any wood comes from the maintenance and what do they do with it.

3.3.3. Food (a) (agriculture, livestock)

Monetary valuation (SE): SE has not included food (milk, meat etc) as a service as these are rather benefits but the Ministry of Environment and Estonian Environmental Agency thought these should be added as services Should milk, meat, wool and other products be considered as ecosystem services (the Ministry of Environment and Estonian Environmental Agency thought these should be added)?

Answer (NL): It is a benefit, not a service. In monetary terms it is not SEEA and SNA consistent because livestock is already part of the economy so it is not an ecosystems service.

3.3.4. Food (b) (wild plants, wild animals, fish).

Monetary valuation (SE): SE is thinking of using the price of marketed known grassland berries and mushrooms. We are working out the availability and detail of amounts marketed. For game (also game birds) and fish we are not sure what the contribution of grassland ecosystems is. It could be done trans-ecosystem.

Question (SE): Are hunting and fishing provisioning or recreational activities? Same about berries and mushroom gathering? Both aspects (provisioning and recreational) are present in these activities.

Answer: Should decide if it is treated as a provisioning or cultural service. When treating it as a cultural service, the method should be different, so it should be treated as provisioning if there is already data and method for that. A way to get information on the amounts collected is via a survey on collected amounts and their places. That method also includes household use. Then multiply it with market price, no need to deduct intermediate costs. Division between ecosystem types can then also be done based on a survey.

3.3.5. Medical Herbs

Monetary valuation (SE): SE is thinking of using the price of known marketed medical herbs. We have the amounts marketed in 2015 from a survey in Estonia and based on this (if we cannot get newer data) we can calculate the monetary value of use. ELME Project helps us distribute the supply between grassland ecosystem types. There is also a household consumption that we don't know how to value and integrate into the evaluation.

Comment (NL): Questions and approaches same as with wild food.

3.3.6. Carbon sequestration, it is part of the carbon account.

Biophysical valuation method (NL): look-up-table of the amount of carbon uptake for each vegetated ecosystem combined with ecosystem map. Look-up-table values from literature, are consistent with LULUCF but map is not harmonized with LULUCF. When you have range of values, you can add error bars or take average. For different types of grasslands, need more information about ecosystem location and C sequestration ability, also soil moisture influences it.

Monetary valuation (SE): Applying PES (payment for ecosystem services) scheme approach. Idea is to use the average price of CO_2 (€/t) in the EU Emissions Trading System. Service value would be allocated based on the ability of grassland ecosystem type to sequestrate carbon.

Comment (NL): Only positive contribution is included into ecosystem service valuation, if carbon is emitted by the ecosystem (ecosystem disservice) then it is not included in monetary accounts. Calculations are done on net carbon sequestration, i.e. what is left in the ground or biomass after emissions.

Question (SE): Is it correct to use average prices of CO_2 per year? Another option is to use the sum of all transactions done during the year but then it is difficult to find the unit CO_2 price.

Answer: EU ETS prices may be low. Using average price per year is OK. But you could also look at the social cost of carbon.

Question (SE): How spatial is Dutch approach?
Answer: If you know where C sequestration is taking place, you can produce a map on that.

3.3.7. Pollination

Biophysical valuation method (NL): combining parcel registry (spatial data), pollination demand per crop, suitability of ecosystem as habitat, maximum distance between habitat and crops can model pollination service (contribution to avoided product loss). Only wild bees were included.

Look-up-table of pollination demand per crop should also apply for Estonia. Table based on the classification used for the pollination requirements for the Atlas Natuurlijk Kapitaal (ANK) and the classification of Klein et al. (2007) "Importance of pollinators in changing landscapes for world crops".

3.3.8. Natural pest control

Biophysical valuation method (NL): similar to pollination. Only one species of ladybugs taken into consideration. Combining ecosystem map forest classes (supplying ecosystem), parcel registry (demanding crops), distance covered between habitat and agricultural field service was modelled

3.3.9. Protection against heavy rainfall

Biophysical valuation method (NL): combining ecosystem map, vegetation maps (trees, shrubs, grass cover in % at 10m resolution), soil map for urban areas, urbanisation level map, infiltration capacity data per soil type (look-up-table) for areas where is no spatial data, interception of precipitation by vegetation (look-up-table). Results have not been checked, maybe done in future.

3.3.10. Protection from flooding

Monetary valuation: NL has not included it yet, maybe it is possible to apply the same method as with protection against heavy rainfall and include floodplains, it is planned as future work, requires modelling. SE monetary valuation method to be considered in future developments is avoided cost method where for valuation insurance data could be used, look at number of people willing to insurance against flooding. There is not a good method that has been agreed upon yet.

3.3.11. Nature recreation and tourism

Tourism and recreation are separated.

Biophysical valuation method, nature recreation (NL): combining statistics on number of hikers for different surroundings per province, ecosystem map, Dutch road database (hiking paths and roads < 4 meters wide) service was modelled considering that all areas of same ecosystem type in a province are equally popular for hiking. Result (a hike) is a combination of number of hikers and kilometres walked. Some problems appear due to how hikers were allocated to roads/ paths in the ecosystem.

The data is collected by a survey sent to households (not by CBS NL itself).

To remove inaccessible or not used paths, Strava (an exercise app) heatmap tiles with hiking intensity, statistics on number of hikers for different surroundings per province were combined and linked to all road segments of topographical map which gives a spatial pattern of hiking intensity. This combined with survey results gives total kilometres hiked per ha*yr in an ecosystem type (service is ecosystem being seen by hikers).

Biophysical valuation method, nature tourism (NL): vacation data from survey similar to recreation survey. Inputs for model: ecosystem map (specific ET provide the service, urban areas removed), statistics on number of booked vacations and average length per province which gives number of overnight stays, types of vacation (nature and active, beach tourism, water sports), data of density of beds in tourist accommodations, for water sports data of density of marinas.

Considerations: international tourists are not included (no survey data).

Experimenting using mobile phone location data for recreation/tourism service.

Monetary valuation (NL): tourism and recreation: all outdoor activities are included in the valuation. Resource rent method beneficiaries are companies, in this method there are many uncertainties, so the approach is not good enough. Consumer expenditure method beneficiaries are households, better method, three different scenarios were looked at. Data was obtained from Dutch tourism and recreation statistics which are based on survey data. Accommodation and food, drinks were included into the method as these businesses are profiting from people visiting the nature areas.

Comment: SE household budget survey may contain similar info/statistics on tourism and recreation as NL statistics.

Monetary valuation (SE): SE tries to apply a method similar to consumer expenditure method but SE do not have such a good record of leisure activities or tourism as Netherlands does. We take a look at specific recreational activities for which people have paid and we have data about, such as recreational fishing, hunting. Also ecotourism activity from EGSS. We also hope to include when we get data on upkeep and develop costs of a hiking trails network in Estonia (RMK). Valuation is done covering all ecosystem types, how to distribute the contribution on different ET is still being decided. CVM study at work.

Question (SE): Are hunting and fishing counted as recreational activities?

Answer: in NL these are included under recreation, provisioning aspect is small. If SE wants to include hunting as provisioning service, it is necessary to calculate how much meat is obtained or number of animals shot. Species can be connected to habitat. Should choose either of the two (provisioning or cultural).

Comment (SE): Accounts for hunting, hunting societies' data (Kaia?)

Question (SE): Can we sum payments for fishing, hunting and hiking trails upkeep costs? These seem to be different monetary flows.

Answer: Yes, these can be summed up.

Question (SE): Should we divide this service for specific smaller services (e.g fishing) to not over- or underestimate it?

Answer: Yes, it's an option. Considering only ecotourism, fishing hunting and hiking trails management costs is probably underestimating the value of the service because you do not look at the real expenditures.

Question (SE): What activities besides hiking, cycling, water sports, outdoor sports are included (under other outdoor recreation)?

Answer: Boat trips, car touring.

Comment (NL): Cultural values have a high value as these are the most used services and their use is most acknowledged.

3.3.1. Amenity service (presentation by Linda de Jongh, NL)

Monetary valuation based on a hedonic pricing model, developed by Daams, Sijtsma and Van der Vlist (2016) "The effect of natural space on nearby property prices: accounting for perceived attractiveness". Dataset of 4.5 million houses that represent the whole population, assessed property values which are close to transaction prices, spatial data on distance to nature (clusters of perceived attractive nature (based on research), other nature (ET map)). Using regression analysis the proportion of house value attributable to nature is found (characteristic: distance to natural areas).

To attribute the results to nature contributing to the house value, asset values were calculated: spatially distribute the value, add all values per cell, and from that service value was calculated.

Very data intensive process.

Comment (SE): In Estonia the market is not so straightforward: in places of beautiful nature, house prices are low. Assumption is that the amenity service is captured in the house price.

3.3.1. Cultural services (presentation by Ilan Havinga, NL)

Two approaches: biophysical (number of people interacting with the ecosystem, e.g. hikers/ha/yr) and monetary (capturing the whole value of ecosystem/ area being seen).

Tourism and recreation services supply divided between ecosystem types based on which ecosystem types/areas are around where activity is taking place. Recreation use side is attributed to households, tourism to accommodation and food service, culture, sports and recreation sector.

Nature tourism, monetary valuation by resource rent method - the residual of the total revenue of an economic activity (tourism, accommodation, restaurants, recreation), after all costs for capital and labour have been subtracted, are allocated between ecosystem types.

Comment (SE): How to take out the costs that are not related to tourism, such as transport? To be discussed later.

Refined concept of cultural services: information-flows generated by ecosystems that contribute to cultural experiences. New geo-tagged data sources, such as mobile phone data, social media provides self-reported information. High data flows indicate where people are going.

Habitat considered as cultural service as you get a sense of fulfilment from being in nature, enjoying the habitat, benefit. Species record as benefit as species presence is the contribution of ecosystem, but human effort is making the benefit, in this case intellectual effort of recording the species.

Sources: Strava, flickr (open, datamining requires coding), Twitter (expensive), iNaturalist.org, eBird, GBIF. Facebook has privacy issues but they may be willing to share data for research work. Google Street view (air filtration based on the greenness in the frame).

Aesthetic services, more precisely landscape presence was valued based on the presence of the landscape to a Flickr user’s photos per day. Shows a good distribution pattern. Issues with representativeness to be solved by filtering in the future.

Possible methods for monetizing: combining with travel cost method (how much time was spent to get to the location to take the photo). Possible to construct a demand curve for travel cost method and supply curve based on marginal costs for maintaining the area, aka simulated exchange method. Paper by Caparrós et al. “Simulated exchange values and ecosystem accounting: Theory and application to free access recreation”. Time spent on the location is not a good method, it represents consumer surplus, not consistent with SNA

Further cooperation on the topic.

3.3.12. Environmental education

Monetary valuation (SE): plan to use subsidies given for environmental education (for example school trips) and also monetary data of institutions who are active in environmental education (the share of their environmental activity is available from EGSS producer list).

Question (SE): Is that approach correct?

Answer: NL has not assessed that service, but that approach of using subsidies seems good. It may be difficult to allocate the result to ecosystem types. Besides using subsidies, you could say that total money spent on env. education (government budget for education) is the value of the service. May be difficult to differentiate education from other related activities. Practical approach would be to look at how much is spent on env. education in EGSS, try differentiate between studies to narrow it down. The number is included in SNA, so when allocating it to ecosystem and then integrating it back to SNA it has to be taken into account. Amount of subsidies may be very small compared to education sector.

Comment (SE): May also look at academic education, the number of scientific papers written on the topic. Survey among universities on the number of people who are doing research in ecology, biodiversity to get the share of env. education. Scientific grants.

Comment (SE): Env. education in schools. Survey on number of nature trips, destination and their cost in schools. Share of nature-related subjects in school programs.

3.3.13. Soil fertility

NL: Soil organic carbon, Netherlands has lot of semisoils that are not fertile by themselves and need nutrients like clay minerals or organic carbon. Soil fertility is wider than only presence of nutrients also ability to absorb and release nutrients is important.

SE: Fertility grades could be considered but for monetary value maybe expenditure on fertilisers could be used. It is too early in Estonia to value this service. We have soil fertility rate that is potential fertility and not actual.

NL: Also soil maps could be used, go to soil survey and ask what information they have.

3.4. Integration into the SNA in NL

Starting point was the basic aggregated National Accounts table where the ecosystem services values were added. The columns of ecosystem services and their calculated values were added to the extended supply table. In use table are identified the users of the services.

Some ecosystem values are already included in SNA (e.g crop production, part of recreation) so corrections were necessary in order to avoid double counting (explained in more detail in NL report). Regulating services were not included to SNA before and therefore give extra value added. Ecosystem services are only supplied by ecosystems and SNA products by industries.

This is a way of integrating ecosystem service data into SNA and in principal give opportunity to show how much ecosystem services are produced compared to what is produced by other industries. This is the first try to integrate ecosystem services into the SNA and could be improved.

NL also introduced integrated asset balance sheets where ecosystem assets were included. Corrections in order to avoid double counting were made. Some indicators are still missing as they do not have a good basis for distribution and improvements are needed. It was seen that the value of culture ecosystems are higher than the value of oil and gas – a way to show that nature has value and ecosystems are contributing to economy.

Report of the ecosystem services valuation will be available online but it is discussed how to publish results to public so that people do not get wrong ideas and conclusions.

4. Conclusions on the methodological issues in Estonia

SE will include asset part in the next grant project and will send the description to Sjoerd to see if our thoughts are feasible.

4.1. List of issues for future discussion. Needs for the improvement and future plans

SE plans to continue with asset valuation next year and also need consultations from NL. Also other ecosystem types and some of the main services are planned to be added and attempt to repeat the making of the extent to see what it takes to make a routine valuation is made and how to classify the changes. SEEA-EEA theories should be tested and SE tries to test some methods (e.g red list ecosystem types).

NL suggested testing the application of European MAES data on usability on national scale (ES national MAES is probably different from European MAES classification). Another important task would be to evaluate the suitability of SEEA-EEA classification for national policy purposes and if the extent maps are useful.

In order to decide what is sensible to be done in the next grant project also national perspective should be considered.

SE will translate Estonian MAES team's questions to English and send these after the study visit (added after this chapter). SE is also interested in NL presentation and reports. SE will also share thoughts about tasks to be considered in the next grant project. SE will write descriptions of methods used and are grateful for NL comments and suggestions.

List of participants:
Statistics Estonia: Ms Kaia Oras, Ms Grete Luukas, Mr Argo Ronk, Ms Kätlin Aun.

Statistics Netherlands: Mr Sjoerd Schenau, Mr Patrick Bogaart, Ms. Linda de Jongh, Mr Ilan Havinga, Mr Edwin Horlings.

ANNEX 2. Seminar summary "Development of the ecoystem extent account and valuation of grassland ecosystem services". November 27-28, 2019, Statistics Estonia

Seminar on the development of the ecoystem extent account and valuation of grassland ecosystem services brought together both the experts from Estonia and abroad and also local stakeholders amd partners.

Statistics Estonia (Kaia Oras) gave an overview of the work done in Estonia on ecosystem accounts in 2019, compiled extent account and valued ecosystem services.

1. Update of the progress so far on the creation of the explicit spatial database on land cover/land use/habitat, developing the extent account and additional data layer by economic and institutional units, and handling the issues how to get from spatial database to ecosystems typology: crosswalks between classification systems.
2. Valuation of ecosystem services regarding grassland ecosystem services, approaches, methods, results.
3. Assembling the ecosystem services in the framework of SNA and supply and use tables.

Representatives of Environmental Ministry and ELME team presented their efforts during last years and set the ecosystem accounts into the wider context of policy e.g. nature conservation action plan. The valuation studies done before were pointed out as useful in current context. The co-ordination of the future tasks on a next more mature phases of the development of the ecoystem extent account was acknowledged by participants.

1. Extent account

Creation of the explicit spatial database on land cover/land use/habitat by multilayer GIS analyses in Statistics Estonia was introduced to participants. Particularities and updating of Estonia's extent account which is currently based on the data from year 2018 were discussed. It was considered that ELME project is also working/finalizing an ecosystem extent map, which would become available by the end of their project by the end of 2020. The creation of the additional data layer by economic and institutional units was welcomed as useful and needed information. The aggregation to main ecosystem types was discussed, Crosswalks from national to international ecosystem type classifications were discussed. EUNIS crosswalk was considered as a feasible approaches for Dutch and UK databases as well. IUCN crosswalks were discussed as a future step and the interest of Estonian users was acknowledged.

2. Ecosystem services valuation

Regarding the ecosystem services selection an assessment of methods, the work on importance, potential data sources, calculation, methods, interests of potential users, Estonian stakeholders query and discussions, consultations with Dutch and UK experts on feasibility were introduced. Selected valuation methods were presented and discussed. It was agreed that it is good that the calculations are done in parallel with various methods and that the integration was performed. It was noted by the project experts that the selection of best methodologies could be still made in later stages and some of the results should still be treated as experimental.

Chosen methods for valuation of provisioning (fodder, medical herbs, raw material for bioenergy, game), regulating (pollination, climate regulation) and cultural (recreation, nature education) services were discussed and were mainly approved on. The conceptual questions raised by the representatives of the ministries and universities regarding the asset and the flow of the ecosystem services were discussed. The somewhat low monetary values of the provided services compared to potential supply values of ecosystems was depicted. The future need of the work in this area was emphasized and the cost of degradation of ecosystem assets was debated in that context. The observable changes in the services values was considered as one of the options to monitor the depletion of the ecosystem asset.

For each service the definition, methodology, alternative applied methods were described (market/non market, CVM study), results and the feasibility of the production of the spatial dimension were discussed and the topics Statistics Estonia is still working on, were acknowledged. The development of the monetary unit values was discussed and it was recognized by the project partners that unit values for ecosystem services could be straightforwardly feasible on a general or aggregate level. It was noted by the project experts that the concepts for the monetary aggregate ha values per single parcels are still very much in development and are hindered by the lack of data for several services on a detailed spatial scale. Spatial analyses of the results was discussed and the feasibility of the application of top-down or bottom-up approaches were argued. The intermediate approach for service values per hectare was proposed as well where the ha-value would be divided into multiple aggregate level values based on qualitative indicators.

As one of the aims of the seminar was to provide the information on the state of art of ecosystem services accounting and valuation on a world level environmental accounting organizations to Estonian stakeholders and scientists, the overview on who is doing what globally regarding the development of ecosystem accounts, UN SEEA EEA revision was given by UK expert and member of the UN SEEA EEA revision group Rocky Harris. UK national work on ecosystem accounts was introduced and institutional setup and the future cooperation in respect of Estonian national case were discussed. For the same purpose a second presentation by Sjoerd Schenau on the Dutch system of ecosystem accounts was given and relations with the Wageningen University and MAES team were discussed.

Methods for the estimation of the grassland ecosystem services were reviewed and revised as follows:
Provisioning services

1. Food (fodder). Both the resource rent and rent price methods were considered to be correct methods but resource rent weakness in the use of several assumptions and therefore rent price was considered more straightforward. Overall resource rent is not as trustworthy as there are no firm data available.
2. Raw materials, bioenergy. Methodology was generally agreed with. There was a discussion on how relevant is the GVA (gross value added) method applied for service valuation. It was acknowledged that the result of GVA method can be used as an ecosystem service value after applying some corrections (deduction of labour costs, depreciation of fixed capital).
3. Medical Herbs: Methodology was generally agreed with. The questions on how could the contribution of the ecosystem be determined in the ecosystem service of provisioning medicinal herbs was addressed. Currently we have taken the whole calculated result as a service value. It was acknowledged that improvements are difficult to make with current available data and that there might be a room for improvements in the follow-up project. Also another approach to consider is applying replacement cost method as in comparing the supply of medicinal herbs with producing artificial medicines.
4. Provisioning of game/hunting service: Methodology was generally agreed with. Currently the whole calculated result as a service value has been taken. It was acknowledged that the whole service value can be considered as an ecosystem contribution. Also that the two different values of provisioning wild game and recreational hunting can be summed as these are different aspects of the service after deducting of the overlapping part.

Regulative services

5. Climate regulation. The results of the applied approaches and concepts (C sequestration and C storage service) were discussed. It was suggested by experts to keep an eye on a next month's UN SEEA EEA expert group outcomes as these questions i.e. the handling of the C sequestration and C storage service are still discussed on international level and definite solutions are currently difficult to give. The same applies for the question how to treat negative values. i.e. disservices. It was acknowledged that carbon storage valued based on CVM is a welfare value and this should not be added up with exchange values. The C storage service provision was decided to be included in assessment of ecosystem services. The conceptual questions would be a subject for future discussions and it would be useful to be described in methodological report.

6. Pollination, methods to be applied. Methodology was generally agreed with and also the use of the spatial data and modelling in order to get best results. Currently there were results of an indirect methods ready but the modelling data are still in work and the co-operation with Wageningen University continues till the results would be available. It was agreed to describe the methods, comparisons and problematic issues in final report. It was discussed if pollination is an intermediate service and how to treat it in supply and use tables to avoid double counting. As Statistics Estonia is valuing only ecosystem services of grasslands in this phase, there is no double counting and the full value of pollination can be added.

Cultural services

7. Nature education. Methodologies were discussed and generally agreed with. Statistics Estonia has to choose a method for assembling of the results. In one hand resource rent to private sector (non-transport) service providers was considered to be surely valid for the accounts, additional (travel) costs of visits could be taken as indicative of WTP for extra benefit from the 'normal lessons as well. It was suggested by Dutch experts to add the values calculated with the expenditure transfer approach, expenditure based approach and travel cost approach as these describe different aspects of the service and different expenditures/costs are used as input data. The latter was chosen. There are still un-answered questions, such as: can the calculated resource rents be applied to other service providers? Is there an element of 'normal lesson costs' which could be attributed to the benefit received from the educational visits?

8. Recreation. Methodologies were generally agreed with. Expenditure costs describe maintenance costs. Time use approach gives a welfare value as a result. It was suggested as improvement that time use approach should only include time spent onsite and that the calculated cost of travel time might be excluded. In addition an alternative approach of household recreation expenditure was discussed, but currently there is no sufficient data for applying it in Estonia. It also needs making some assumptions on average expenditure of a trip based on literature or separate study could be a way to apply this approach. Which approach to choose: the time value or expenditure approach for recreation service? It was concluded that time spent approach should be preferred as the maintenance costs underestimates the value. Regarding the spatial allocation of the service values a simple method to divide values equally over the recreation service providing area was suggested; in the future it can be improved and the location where most of the service is actually provided (which places people visit more often) could be taken into account.

9. Rocky Harris gave a presentation on the valuation of Habitats for species.

Compiled supply and use tables and the differentiation between the SNA and non-SNA benefits were discussed

Rocky Harris presented the theory, state of the play in UN SEEA EEA regarding the SNA and non-SNA benefits. Sjoerd Schenau analyzed Estonia's allocation to cathegories and concluded that provisioning services are part of the SNA (it is possible to make it explicit in the ecosystem accounts and in that case it should be taken out from core SNA), regulatory services are not SNA benefits and cultural and educational services are a mix of SNA and non-SNA benefits as it generally is also agreed by the UN SEEA experts.

Introduction to the ecosystem services supply and use tables developed for the selected services (Grete Luukas, Kaia Oras) was given. Handling intermediate and final services in supply and use tables was introduced by Rocky Harris. Out of the services valued by Statistics Estonia this year only pollination is an intermediate service. It was noted that this should be indicated under "from grassland to cropland" (supplied by grassland to cropland) and in the use table under "ecosystem" (as the service is used by another ecosystem) . As this year handle only services provided by grasslands, it is not yet important to distinguish intermediate services. Kaia Oras informed that regarding the supply and use tables the consultations have started with Alessandra La Notte from JRC but the results have not been updated yet.

Potential and actual supply was introduced by Rocky. The different meaning nehind the definitions of potential and actual supply by various players (MAES and UN SEEA teams) was disputed. In case of fodder we have actual supply on aggregate level but not on spatial level. Our experts still do not do it on spatial level. Dutch apply the average factors for the spatial distribution. Potential supply would be handled in more detail in the grant project next year when forestry and timber will be handled. It was concluded that actual and potential supply will be a an issue for the allocation on local spatial scale.

The bases for the analyses of the services of the cultivated and non-cultivated grasslands were discussed in a smaller group in a break up session as well as the data sources for carrying out the analyses on the policy use of the results. Table on the total and hectare values of the ecosystem services was presented discussed. The local spatial and the aggregate level of analyses was depicted as an important aspect to consider. The availability of the detailed comparable spatial data on environmental incentives and resource taxes and respective tax base as well as ecosystem services provided are triggering currently the analyses on a detailed spatial scale. However the service values could probably quite effectively be analyzed on a more aggregated e.g. intermediate ecosystem type level. The feasibility of this analyses was proposed as a future work when the results of this grant work will become available.

Discussions: The problems encountered and possible future tasks to be taken.
Conclusions on the methodological issues were discussed It was agreed that it is too early to make final decisions regarding several methodological issues as several methodological questions are still open as UN SEAA EEA is still in development phase.

Discussion of the starting grantwork 2020-21 were touched upon briefly and general agreement on collaboration was reached among partners and experts.

Tallinn, 09.12.2019, Kaia Oras

List of participants

Name	Position, function
Statistics Estonia	
Ms Kaia Oras	Team leader of environment statistics and accounts in Economic and Environment Statistics Service
Ms Grete Luukas	Leading analyst, responsible for the compiling of the monetary environmental accounts;
Mr Argo Ronk	Leading analyst, responsible for ecosystem extent account and for a certain selection of services
Ms Kätlin Aun	Analyst, responsible for ecosystem extent account and the selection of services
Mr Veiko Adermann	Analyst, technical solutions on registry and spatial data, conversion to EUNIS and LULUCF
Quests:	
Ms Madli Linder	Project leader of ELME, Environmental Agency
Ms Merit Otsus	MAES and IPBES focal point in Estonia, Ministry of Environment
Ms Kaja Lotman	Ecosystem services and nature education, ELME, Environmental Board
Ms Aveliina Helm	Grassland expert, professor of Tartu University
Mr Liina Remm	Habitats expert, ELME
Ms Liisa Puusepp	Environmental education and ecosystem Services, Ministry of Environment
Mr Üllas Ehrlich	Project- expert, Tallinn Technical University, professor of ecological economics
Ms Aija Kosk	Project- expert, Tartu College of Tallinn Technical University, lecturer in ecological economics
Ms Tea Nõmmann	Project expert, researcher, Tallinn Technical University
Ms Helen Sooväli –Sepping	Tallinn University, School of Natural Sciences and Health, professor, ELME, environmental education
Mr Roderick Harris	Adviser, Project leader on Environmental Accounts (physical and monetary)
SKYPE	
Mr Sjoerd Schenau	Project leader Environmental Accounts (physical and monetary),
Mr Patrick Bogaart	Researcher in ecosystem accounts

ANNEX 3. Details of data sources and accompanying attributes for the data used in order of compiling ecosystem unit map. Priority refers to ordering, how data layers were prioritized in case of overlaps. Ecosystem type refers to LULUCF classification as how we regarded the mapping units in broad class.

Priority	Ecosystem type	Data	Source	Classification	Number of classes	Data Type	Date accessed	Link
1	Cropland/ Grassland/ Other	Agricultural land and semi-natural habitats (Support bases)	Estonian Agricultural Registers and Information Board	Original/local	8	Vector	21.01.2019	https://kls.pria.ee/kaart/
2	Forest land	Forest types	Forest registry of Estonia	Original/local	32	Vector	11.01.2019	https://register.metsad.ee/#/
3	Wetland/ Forest land/ Grassland/ Other	Wetlands	Estonian Nature Foundation	Natura 2000 habitats	57	Vector	23.01.2019	http://www.soo.ee/kaardirakendus-
4	Grassland/ Wetland/ Other	Semi-natural habitats which are eligible for support	Estonian Nature Information System	Natura 2000 habitats	15	Vector	21.01.2019	http://register.keskkonnainfo.ee/envreg/main;jsessionid=JShsdnXCvZ114YJTlblpKsh0pcQTft46C14CybKx65jpsyp7G0rT!-1855651664#HTTP8QnLA6IRTgVkXWEOrW5pOXRwtte4Nm
5	Forest land/ Grassland/ Wetland/ Other	Natura 2000 habitats (Annex I habitats)	Estonian Nature Information System	Natura 2000 habitats	60	Vector	23.01.2019	http://register.keskkonnainfo.ee/envreg/main;jsessionid=JShsdnXCvZ114YJTlblpKsh0pcQTft46C14CybKx65jpsyp7G0rT!-1855651664#HTTP8QnLA6IRTgVkXWEOrW5pOXRwtte4Nm
6	Grassland	Meadows	Estonian Seminatural Community Conservation Association	Natura 2000 habitats	12	Vector	23.01.2019	http://www.pky.ee/
7	Cropland/ Forest land/Grassland/Wetland/Settlements/Other	Estonian Topographic Database	Land Board of Estonia	Original/local	34	Vector	03.01.2019	https://geoportaal.maaamet.ee/est/Ruumiandmed/Eesti-topograafia-andmekogu-p79.html

ANNEX 4. Grasslands ecosystems classification

Level	Ecosystem type	Status
1.	Grassland	
1.1.	Semi-natural grassland	
1.1.1.	Semi-natural grasslands according to the NATURA classification	
1.1.1.1.	1630 - Boreal baltic coastal meadows	Confirmed
1.1.1.2.	2130 - Fixed coastal dunes with herbaceous vegetation (“grey dunes”)	A dune area that may be heathy grassland. Typical beach meadow. Confirmed.
1.1.1.3.	2320 - Dry sand heaths with Calluna and Empetrum nigrum	A dry sand heaths; more loose sand compared to 2330; coastal grasslands. Confirmed.
1.1.1.4.	2330 - Inland dunes with open Corynephorus and Agrostis	Dry sand heaths, coastal grasslands. Confirmed. added
1.1.1.5.	4030 - European dry heaths	Confirmed
1.1.1.6.	5130 - Juniperus communis formations on heaths or calcareous grasslands	Confirmed
1.1.1.7.	6120 - Xeric sand calcareous grasslands	Confirmed
1.1.1.8.	6130 - Calaminarian grasslands of the Violetaliacalaminariae	Confirmed
1.1.1.9.	6210 - Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	Confirmed
1.1.1.10.	6270 - Fennoscandian lowland species-rich dry to mesic grasslands	Confirmed
1.1.1.11.	6280 - Nordic alvar and precambrian calcareous flatrocks	Confirmed
1.1.1.12.	6410 - Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	Confirmed
1.1.1.13.	6430 - Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	Confirmed
1.1.1.14.	6450 - Northern boreal alluvial meadows	Confirmed
1.1.1.15.	6510 - Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	Confirmed
1.1.1.16.	6530 - Fennoscandian wooded meadows	Very thin forest, more like grassland. Move to forest partially in future?
1.1.1.17.	9070 - Fennoscandian wooded pastures	Single small pieces of forest with large patches of grassland.
1.1.2.	Other semi-natural grassland*	Confirmed
1.2.	Cultivated grassland	Confirmed
1.2.1.	Permanent grassland	Confirmed
1.2.1.1.	Environmental non-sensitive permanent grassland	Confirmed
1.2.1.2.	Environmental sensitive permanent grassland	Confirmed
Memo items**		
2.	Agricultural land	
	Short term grassland	Agreed that this is agricultural land. Exclude from grasslands.
	Short term grassland	Exclude from grasslands
	Restored grassland	Exclude from grasslands

* - other semi-natural grassland refer for the grasslands which have been identified according to the presence on Estonian topographic map and for which no other information is available.

** - memo item: short term grasslands are not part of the grasslands and are considered to be agricultural land. They are displayed from the point of view of general information.

ANNEX 5. Crosswalk table from Estonian ecosystem units classification to EUNIS and UNFCCC IPCC LULUCF

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
1110	NATURA code[128]	Sandbanks which are slightly covered by sea water all the time	Other land	A5	Sublittoral sediment
1130	Natura code	Estuaries	Wetland	X01	Estuaries
1140	Natura code	Mudflats and sandflats not covered by seawater at low tide	Other land	A2	Littoral sediment
1150	Natura code	Coastal lagoons	Wetland	A5	Sublittoral sediment
1160	Natura code	Large shallow inlets and bays	Other land	A	Marine habitats
1170	Natura code	Reefs	Other land	A4	Circalittoral rock and other hard substrata
1210	Natura code	Annual vegetation of drift lines	Other land	B2.12	Atlantic and Baltic shingle beach drift lines
1220	Natura code	Perennial vegetation of stony banks	Other land	B2.3	Upper shingle beaches with open vegetation
1230	Natura code	Vegetated sea cliffs of the Atlantic and Baltic Coasts	Other land	B3.32	Vegetated Baltic gently sloping rocky shores and cliffs
1310	Natura code	Salicornia and other annuals colonizing mud and sand	Other land	A2.5	Coastal saltmarshes and saline reedbeds
1620	Natura code	Boreal Baltic islets and small islands	Other land	B3.24	Unvegetated Baltic rocky shores and cliffs
1630	Natura code	Boreal Baltic coastal meadows	Grassland	A2.5	Coastal saltmarshes and saline reedbeds

[128] NATURA codes which are in use in a severa sources: PLK, PRIA, NATURA 2000, PKÜ, Wetlands database.

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
1640	Natura code	Boreal Baltic sandy beaches with perennial vegetation	Grassland	B1.121	Baltic sand beach annual communities
2110	Natura code	Embryonic shifting dunes	Other land	B1.31	Embryonic shifting dunes
2120	Natura code	Shifting dunes along the shoreline with Ammophila arenaria ('white dunes')	Other land	B1.32	White dunes
2130	Natura code	Fixed coastal dunes with herbaceous vegetation ('grey dunes')	Grassland	B1.4	Coastal stable dune grassland (grey dunes)
2140	Natura code	Decalcified fixed dunes with Empetrum nigrum	Other land	B1.51	Crowberry brown dunes
2180	Natura code	Wooded dunes of the Atlantic, Continental and Boreal region	Forest land	B1.7	Coastal dune woods
2190	Natura code	Humid dune slacks	Other land	B1.8	Moist and wet dune slacks
2320	Natura code	Dry sand heaths with Calluna and Empetrum nigrum	Grassland	F4.261	Dry sandy heaths with crowberry
2330	Natura code	Inland dunes with open Corynephorus and Agrostis grasslands	Grassland	E1.9	Open non-Mediterranean dry acid and neutral grassland, including inland dune grassland
2680	Natura code	*non-existing code*	Other land		
3110	Natura code	Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae)	Wetland	C1.1	Permanent oligotrophic lakes, ponds and pools
3130	Natura code	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea	Wetland	C1.2	Permanent mesotrophic lakes, ponds and pools
3140	Natura code	Hard oligo-mesotrophic waters with benthic vegetation of Chara spp	Wetland	C1	Surface standing waters

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
3150	Natura code	Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation	Wetland	C1.3	Permanent eutrophic lakes, ponds and pools
3160	Natura code	Natural dystrophic lakes and ponds	Wetland	C1.4	Permanent dystrophic lakes, ponds and pools
3180	Natura code	Turloughs	Other land	C1.6	Temporary lakes, ponds and pools
3260	Natura code	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation	Wetland	C2	Surface running waters
4030	Natura code	European dry heaths	Grassland	F4	Temperate shrub heathland
5130	Natura code	Juniperus communis formations on heaths or calcareous grasslands	Grassland	F3.16	Common juniper scrub
6120	Natura code	Xeric sand calcareous grasslands	Grassland	E1.1	Inland sand and rock with open vegetation
6130	Natura code	Calaminarian grasslands of the Violetalia calaminariae	Grassland	E1.B	Heavy-metal grassland
6210	Natura code	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)	Grassland	E1.2	Perennial calcareous grassland and basic steppes
6270	Natura code	Fennoscandian lowland species-rich dry to mesic grasslands	Grassland	E2.24	Boreal and sub-boreal meadows
6280	Natura code	Nordic alvar and precambrian calcareous flatrocks	Grassland	E1.2	Perennial calcareous grassland and basic steppes

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
6410	Natura code	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	Grassland	E3.5	Moist or wet oligotrophic grassland
6430	Natura code	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	Grassland	E5.4	Moist or wet tall-herb and fern fringes and meadows
6450	Natura code	Northern boreal alluvial meadows	Grassland	E3.47	Northern boreal alluvial meadows
6510	Natura code	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	Grassland	E2.24	Boreal and sub-boreal meadows
6530	Natura code	Fennoscandian wooded meadows	Forest land | Grassland	X09	Pasture woods (with a tree layer overlying pasture)
6540	Natura code	Sub-Mediterranean grasslands of the Molinio-Hordeion secalini	Grassland	E	Grasslands and lands dominated by forbs, mosses or lichens
7110	Natura code	Active raised bogs	Wetland	D1.11	Active, relatively undamaged raised bogs
7120	Natura code	Degraded raised bogs still capable of natural regeneration	Wetland	D1.121	Damaged, inactive bogs, dominated by dense purple moorgrass (Molinia])
7140	Natura code	Transition mires and quaking bogs	Wetland	D2.3	Transition mires and quaking bogs
7150	Natura code	Depressions on peat substrates of the Rhynchosporion	Wetland	D2.3	Transition mires and quaking bogs
7160	Natura code	Fennoscandian mineral-rich springs and springfens	Wetland	C2.111	Fennoscandian mineral-rich springs and springfens

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
7210	Natura code	Calcareous fens with Cladium mariscus and species of the Caricion davallianae	Wetland	D5.24	Fen beds of great fen sedge ([Cladium])
7220	Natura code	Petrifying springs with tufa formation (Cratoneurion)	Wetland	C2.1	Springs, spring brooks and geysers
7230	Natura code	Alkaline fens	Wetland	D4.1	Rich fens, including eutrophic tall-herb fens and calcareous flushes and soaks
8210	Natura code	Calcareous rocky slopes with chasmophytic vegetation	Other land	H3.2C	Boreal calcareous cliff communities
8220	Natura code	Siliceous rocky slopes with chasmophytic vegetation	Other land	H3.1	Acid siliceous inland cliffs
8240	Natura code	Limestone pavements	Other land	H3.511	Limestone pavements
8310	Natura code	Caves not open to the public	Other land	H1	Terrestrial underground caves, cave systems, passages and waterbodies
9010	Deleted	Western Taiga	Forest land	G3	Coniferous woodland
9020	Deleted	Fennoscandian hemiboreal natural old broad-leaved deciduous forests (Quercus, Tilia, Acer, Fraxinus or Ulmus) rich in epiphytes	Forest land	G1	Broadleaved deciduous woodland
9050	Deleted	Fennoscandian herb-rich forests with Picea abies	Forest land	G3.A	Spruce taiga woodland
9060	Deleted	Coniferous forests on, or connected to, glaciofluvial eskers	Forest land		
9070		Fennoscandian wooded pastures	Forest land	X09	Pasture woods (with a tree layer overlying pasture)

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
9080	Deleted	Fennoscandian deciduous swamp woods	Forest land	G1.5	Broadleaved swamp woodland on acid peat
9180	Deleted	Tilio-Acerion forests of slopes, screes and ravines	Forest land	G1.A	Meso- and eutrophic oak, hornbeam, ash, sycamore, lime, elm and related woodland
91D0	Deleted	Bog woodland	Forest land	G	Woodland, forest and other wooded land
91E0	Deleted	Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)	Forest land	G1.12	Boreo-alpine riparian galleries
91F0	Deleted	Riparian mixed forests of Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers (Ulmenion minoris)	Forest land	G1.2	Mixed riparian floodplain and gallery woodland
Aianduslik maa	ETAK	Kitchen gardens	Settlements	I1.2	Mixed crops of market gardens and horticulture
AN	Forest register	Filipendula site type	Forest land	G	Woodland, forest and other wooded land
Biotiik	ETAK	Bio-pond	Settlements	J5.3	Highly artificial non-saline standing waters
Eraõu	ETAK	Private garden	Settlements	J	Constructed, industrial and other artificial habitats
Haljasala	ETAK	Green area in settlements	Settlements	X11	Large parks
Jäätmaa	ETAK	Barren vegetation	Settlements	H5	Miscellaneous inland habitats with very sparse or no vegetation

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
Järv	ETAK	Lake	Wetland	C1	Surface standing waters
JK	Forest register	Oxalis site type	Forest land	G	Woodland, forest and other wooded land
JM	Forest register	Oxalis-Myrtillus site type	Forest land	G	Woodland, forest and other wooded land
JO	Forest Register	Oxcalis drained swamp site type	Forest land	G	Woodland, forest and other wooded land
JP	Forest Register	Oxalis-Rhodococcum site type	Forest land	G	Woodland, forest and other wooded land
Kalmistu	ETAK	Cemetery	Settlements	J4	Transport networks and other constructed hard-surfaced areas
Karjäär	ETAK	Excavation sites	Settlements	J3.2	Active opencast mineral extraction sites, including quarries
Karjatamine väljaspool põllumaj. maad	PRIA	Grazing outside of agricultural areas	Grassland	X09	Pasture woods (with a tree layer overlying pasture)
Keskkonnatundlik püsirohumaa	PRIA	Environmentally sensitive permanent grassland	Grassland	I1.3	Arable land with unmixed crops grown by low-intensity agricultural methods
KL	Forest Register	Galamagrostis-alvar site type	Forest land	G	Woodland, forest and other wooded land
Klibune ala	ETAK	Coastal shingle	Other land	B2	Coastal shingle
KM	Forest Register	Polytrichum-Myrtillus site type	Forest land	G	Woodland, forest and other wooded land
KN	Forest Register	Calluna site type	Forest land	G	Woodland, forest and other wooded land

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
KP	Forest Register	Reclamationed pits site type	Forest land	G	Woodland, forest and other wooded land
KR	Forest Register	Polytrichum site type	Forest land	G	Woodland, forest and other wooded land
KS	Forest Register	Drained swamp site type	Forest land	G	Woodland, forest and other wooded land
Laugas	ETAK	Raised bog pools	Wetland	C1.46	Raised bog pools
LD	Forest Register	Alder (eutrophic) fen site type	Forest land	G	Woodland, forest and other wooded land
Lennuväli	ETAK	Airport runway	Settlements	J4.4	Airport runways and aprons
Liivane ala	ETAK	Sandy shore	Other land	B1	Coastal dunes and sandy shores
LL	Forest Register	Arctostaphylos-alvar site type	Forest land	G	Woodland, forest and other wooded land
LP	Forest Register	Reclamationed pits site type	Forest land	G	Woodland, forest and other wooded land
LU	Forest Register	Sesleria-alvar site type	Forest land	G	Woodland, forest and other wooded land
Lühiajaline rohumaa	PRIA	Short term grass field	Cropland	I1.1	Intensive unmixed crops
Madalsoo	ETAK	Alder-birch (eutrophic-mesotrophic) swamp site type	Wetland	D2.2	Poor fens and soft-water spring mires
Mahajäetud turbaväli	ETAK	Abandoned peatlands	Wetland	D1.12	Damaged, inactive bogs
MD	Forest Register	Alder-birch (eutrophic-mesotrophic) swamp site type	Forest land	G	Woodland, forest and other wooded land
Mets	ETAK pole enam	Forest	Forest land	G	Woodland, forest and other wooded land

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
MO	Forest Register	Myrtillus drained swamp site type	Forest land	G	Woodland, forest and other wooded land
MP	Forest Register	Reclamationed pits site type	Forest land	G	Woodland, forest and other wooded land
MS	Forest Register	Myrtillus site type	Forest land	G	Woodland, forest and other wooded land
Mustkesa	PRIA	Unplanted fallow	Cropland	I1.1	Intensive unmixed crops
Muu	ETAK	*other*	Other land		
Muu lage	ETAK	inland habitats with no vegetation	Settlements	H5	Miscellaneous inland habitats with very sparse or no vegetation
ND	Forest Register	Aegopodium site type	Forest land	G	Woodland, forest and other wooded land
Õõtsik	ETAK	Quaking bogs	Wetland	D2.3	Transition mires and quaking bogs
OS	Forest Register	Equisetum site type	Forest land	G	Woodland, forest and other wooded land
Paisjärv	ETAK		Wetland	C1	Surface standing waters
PH	Forest Register	Rhodococcum site type	Forest land	G	Woodland, forest and other wooded land
Põld	ETAK	Arable land	Cropland	I1	Arable land and market gardens
Põllukultuurid	PRIA	Cropland	Cropland	I1.1	Intensive unmixed crops
Põõsastik	ETAK	Shrubbery	Grassland	F3.1	Temperate thickets and scrub
Prügila	ETAK	Landfill	Settlements	J6	Waste deposits

Ecosystem type code on an explicit map	Source where the category is/could be derived	Description ENG	UNFCCC IPCC LULUCF	EUNIS	EUNIS description
Püsikultuurid	Forest Register	Permanent crops	Cropland	I1.2	Mixed crops of market gardens and horticulture
Püsirohumaa	PRIA	Permanent grassland	Grassland	I1.3	Arable land with unmixed crops grown by low-intensity agricultural methods
Raba	ETAK	Oligotrophic bog site type	Wetland	D1.11	Active, relatively undamaged raised bogs
RB	Forest Register	Oligotrophic bog site type	Forest land	G	Woodland, forest and other wooded land
Rohumaa	ETAK	Grassland	Grassland	E	Grasslands and lands dominated by forbs, mosses or lichens
Roostik	ETAK	Reed	Other land	C3.21	Common reed ([Phragmites]) beds
Sadam	ETAK	Port	Settlements	J4	Transport networks and other constructed hard-surfaced areas
SJ	Forest Register	Dryopteris site type	Forest land	G	Woodland, forest and other wooded land
SL	Forest Register	Hepatica site type	Forest land	G	Woodland, forest and other wooded land
SM	Forest Register	Cladonia site type	Forest land	G	Woodland, forest and other wooded land
SN	Forest Register	Vaccinium uliginosum site type	Forest land	G	Woodland, forest and other wooded land
Soovik	ETAK	Moist mesotrophic grassland	Other land	E3.4	Moist or wet eutrophic and mesotrophic grassland

Ecosystem type code on an explicit map	**Source where the category is/could be derived**	**Description ENG**	**UNFCCC IPCC LULUCF**	**EUNIS**	**EUNIS description**
SP	Forest Register	Reclamationed pits site type	Forest land	G	Woodland, forest and other wooded land
Spordikompleks	ETAK	Area used for sport activities	Settlements	J1	Buildings of cities, towns and villages
SS	Forest Register	Transitional (mesotrophic) bog site type	Forest land	G	Woodland, forest and other wooded land
TA	Forest Register	Carex-Filipendula site type	Forest land	G	Woodland, forest and other wooded land
Tagasirajatud rohumaa	PRIA	Restored grassland	Cropland	I1.1	Intensive unmixed crops
Täitmata	ETAK	*no data*	Other land		
Tee	ETAK	Roads	Settlements	J4	Transport networks and other constructed hard-surfaced areas
Tehisjärv	ETAK	Artificial waterbodies	Wetland	C1	Surface standing waters
Tiik	ETAK	Pond	Wetland	J5.3	Highly artificial non-saline standing waters
Tootmisõu	ETAK	Industrial site	Settlements	J1.4	Urban and suburban industrial and commercial sites still in active use
TP	Forest Register	Reclamationed pits site type	Forest land	G	Woodland, forest and other wooded land
TR	Forest Register	Carex site type	Forest land	G	Woodland, forest and other wooded land
Turbaväli	ETAK	Peatland, extraction site	Wetland	J3.2	Active opencast mineral extraction sites, including quarries
Vooluveekogu	ETAK	Surface running waters	Wetland	C2	Surface running waters

ANNEX 6. Estonian grassland ecosystem types by activity sectors and economic activities, ha, 2019

Grassland ecosystem type / Activity sector	1630	2130	2320	2330	4030	5130	6120	6130	6210	6270	6280	6410	6430	6450	6510	6530	9070	Environmental sensitive permanent grassland	Environmental non-sensitive permanent grassland	Other natural grassland	**TOTAL**
Financial corporations_K	19				0	7			9	4	10	0	2	2	7	0	1		97	105	**263**
General government_H						0														0	**0**
General government_J																					**0**
General government_L	1									1	2		1	8	10				3	58	**84**
General government_M																					**0**
General government_N	0																				**0**
General government_O	220	12	2		200	59	0	0	279	311	614	122	295	1308	717	301	93	46	28737	14332	**47649**
General government_OTHER	2118	33	6	1	8	92	1	0	140	125	338	32	148	852	149	124	50	12	2033	8554	**14815**
General government_P	0					0				0		0	11	151	0	8			217	120	**506**
General government_Q									0										1	61	**62**
General government_R	0								0	2				3	0	0	1		26	27	**59**
Households	6384	76	18	0	124	1898	19	0	1968	2320	5826	895	944	4250	1896	1685	1117	163	87471	59822	**176876**
Households_A1	1610	6	3		26	340		0	678	849	1302	172	297	1527	653	579	706	163	63623	13833	**86365**
Households_A2	163	1			0	21			34	112	75	34	35	265	44	57	29	6	4004	2491	**7370**
Households_A3	192	1	0		2	36			39	46	93	32	4	28	14	31	42		634	370	**1564**
Households_B														2					53	8	**63**
Households_C	55	0			0	4			17	17	25	8	7	28	13	12	3		703	454	**1346**
Households_D	0					1			0	3	1			1		1			3	10	**20**
Households_E														0					0	3	**4**
Households_F	44				2	16			20	19	43	12	8	33	12	13	16	0	626	508	**1373**
Households_G	37	0			0	14			17	39	40	25	6	57	20	14	9	2	1048	681	**2009**
Households_H	64	2			0	34	0		24	26	48	8	17	39	22	17	26	2	1054	549	**1932**
Households_I	25		1		0	17			12	11	32	3	1	19	8	5	13		409	200	**755**
Households_J	37				2	5			12	13	27	3	21	16	2	6	6		272	182	**605**

Grassland ecosystem type / Activity sector	1630	2130	2320	2330	4030	5130	6120	6130	6210	6270	6280	6410	6430	6450	6510	6530	9070	Environmental sensitive permanent grassland	Environmental non-sensitive permanent grassland	Other natural grassland	**TOTAL**
Households_K	4					3			2	7	10	5	1	10	2	5	1		148	99	**295**
Households_L	68	0	1		0	1	2		16	23	34	14	4	65	19	50	3		698	381	**1380**
Households_M	87		0			48	0		23	24	43	4	10	35	25	31	17		886	532	**1765**
Households_N	84	0	0		3	29	1		44	43	116	30	31	64	32	13	35		1138	822	**2486**
Households_P	16		0			20			5	9	15	3	1	9	6	2	2		282	162	**531**
Households_Q	13		0			3			3	3	20	3	4	6	1	1	0		243	157	**459**
Households_R	57	0	1			25			18	29	29	6	14	20	11	41	20		636	414	**1322**
Households_S	124	3	0		0	41			37	31	80	6	8	52	32	38	40	2	1353	782	**2629**
Non financial corporations	477			1	5	53	0		161	381	441	287	242	1438	315	221	46	0	11694	12380	**28144**
Non financial corporations_A1	243				0	27			127	188	275	39	188	591	175	129	74	78	27782	5939	**35856**
Non financial corporations_A3	0									1	0	0	0	12	1	8	2		43	55	**123**
Non financial corporations_B	14					1					83	1	2	1	10	0	0		159	216	**487**
Non financial corporations_C	18	1				3			17	21	25	9	4	31	7	6	3		526	776	**1447**
Non financial corporations_D	34	0				9			156	5	500	1	5	0	4	2	0	0	216	395	**1327**
Non financial corporations_E	6				0	6			1	3	1	0	1	25	1	0	1	0	24	310	**377**
Non financial corporations_F	59			2	1	8			15	8	64	4	6	79	11	17	1	0	418	717	**1411**
Non financial corporations_G	95	0			2	27			16	18	76	18	5	31	25	2	1	0	744	764	**1824**
Non financial corporations_H	32	2			14	7			6	8	26	6	5	10	6	3	1	0	225	705	**1054**
Non financial corporations_I	66	1			0	15			6	4	43	2	0	15	18	3	19		399	278	**870**
Non financial corporations_J	22					7			3	3	5	7		7	5	1	0		102	147	**308**
Non financial corporations_L	638	21	1		3	127			128	130	502	104	61	262	88	74	37	7	8045	4171	**14400**
Non financial corporations_M	97	1	0		2	35			24	22	102	13	14	15	22	12	4	1	707	552	**1621**
Non financial corporations_N	40	0			5	9			18	5	19	3	18	21	3	6	2		411	357	**918**
Non financial corporations_OTHER	46		2		0	12			20	4	64	8	10	25	10	16	1		441	491	**1152**
Non financial corporations_P	1	3			0	1			8	3	8	2	0	0		0	0		52	62	**141**
Non financial corporations_Q	0									0				0	1	5			5	17	**30**

Grassland ecosystem type / Activity sector	1630	2130	2320	2330	4030	5130	6120	6130	6210	6270	6280	6410	6430	6450	6510	6530	9070	Environmental sensitive permanent grassland	Environmental non-sensitive permanent grassland	Other natural grassland	**TOTAL**
Non financial corporations_R	12				0				8	1	20		3	7	3	2			122	169	**345**
Non financial corporations_S						1				0	3			0	1				26	66	**97**
NPISH_L	0								0	1	1			1	1				0	42	**45**
NPISH_P												0							1	3	**4**
NPISH_Q									0	1	0	0							5	21	**28**
NPISH_R	9					0			0	3	1		0	3	2	2	0		78	123	**222**
NPISH_S	111	1	0		0	26			27	23	61	5	19	70	44	15	3	0	476	397	**1277**
Rest of the world	1191	9	6		6	249	9		241	155	711	113	32	122	80	118	63	12	2385	2278	**7780**
State Forest Management Centre	5195	221	1	24	154	471			974	1055	2712	1636	1135	13735	750	872	466	59	3371	6428	**39261**
State Forest Management Centre_A2																				1	**1**
Unknown	116	2	0	0	1	32	0	0	29	63	48	19	19	462	70	20	11	0	1144	1333	**3369**
Total	**19 946**	**397**	**43**	**27**	**561**	**3 837**	**32**	**0**	**5 381**	**6 175**	**14 616**	**3 693**	**3 641**	**25 811**	**5 348**	**4 569**	**2 965**	**554**	**255 998**	**144 909**	**498 506**

ANNEX 7. Land area by institutional sector according to EUNIS habitat classes, ha

Institutional sector	Coastal saltmarshes and saline reedbeds	Sublittoral sediment	Coastal dunes and sandy shores	Baltic sand beach annual communities	Embryonic shifting dunes	White dunes	Coastal stable dune grassland (grey dunes)	Crowberry brown dunes	Moist and wet dune slacks	Coastal shingle	Atlantic and Baltic shingle beach drift lines	Upper shingle beaches with open vegetation	Unvegetated Baltic rocky shores and cliffs	Vegetated Baltic gently sloping rocky shores and cliffs	Surface standing waters	Permanent oligotrophic lakes, ponds and pools	Permanent mesotrophic lakes, ponds and pools
General government	2 359	81	213	68	28	38	45	2	1	22	30	30	147	9	7 122	0.00	2
Non financial corporations	1 906	20	35	15	11	9	29	2	3	17	35	15	21	7	764	0.04	0.04
Financial corporations	19	2	0.18		0.02					1		2			6		
Households	9 083	81	76	62	21	51	91	4	19	34	82	87	106	10	2 531	0.36	7
NPISH	121	1	2	0.15			1			0.24	0.25	0.42	0.06	0.03	15		
Rest of the world	1 191	6	9	16	6	2	9	4	1	4	17	12	14	3	85		
State Forest Management Centre	5 196	311	112	123	153	115	221	7	54	31	75	106	342	16	14 262	2	7
Unknown	116	15	5	24	1	8	2			1	1	24			952		
TOTAL	**19 991**	**517**	**452**	**308**	**219**	**223**	**397**	**19**	**78**	**109**	**240**	**277**	**630**	**44**	**25 738**	**3**	**16**

Institutional sector	Permanent eutrophic lakes, ponds and pools	Permanent dystrophic lakes, ponds and pools	Raised bog pools	Surface running waters	Springs, spring brooks and geysers	Fennoscandian mineral-rich springs and springfens	Common reed ([Phragmites]) beds	Active, relatively undamaged raised bogs	Damaged, inactive bogs	Damaged, inactive bogs, dominated by dense purple	Poor fens and soft-water spring mires	Transition mires and quaking bogs	Rich fens, including eutrophic tall-herb fens and calcareous	Fen beds of great fen sedge ([Cladium])	Grasslands and lands dominated by forbs, mosses or lichens	Inland sand and rock with open vegetation	Perennial calcareous grassland and basic steppes
General government	58	2	62	3 648	2	42	416	6 575	1 441	2 341	2 519	2 790	1 647	99	23 152	1	1 374
Non financial corporations	7		2	1 763	0.50	104	139	1 155	128	149	2 447	755	2 540	228	28 567	0.44	2 972
Financial corporations	0			3		0.23	3	0.00			10	0.02	6		105		19
Households	30	3	5	3 470	8	271	386	1 931	211	303	5 953	1 729	4 784	696	82 460	22	10 827
NPISH	0			29		1	12	3			37	14	78		586		90
Rest of the world	1		0.22	51		16	32	37	3	16	134	23	270	53	2 278	9	951
State Forest Management Centre	59	13	1 598	2 070	2	402	337	126 023	3 831	7 478	6 374	35 146	20 856	1 335	6 429		3 686
Unknown	1	0.43	142	129		3	14	14 936	167	686	582	2 568	315	27	1 333		77
TOTAL	**156**	**18**	**1 809**	**11 165**	**13**	**839**	**1 340**	**150 659**	**5 780**	**10 974**	**18 056**	**43 025**	**30 497**	**2 437**	**144 909**	**32**	**19 997**

Institutional sector	Open non-Mediterranean dry acid and neutral grassland, including inland dune grassland	Heavy-metal grassland	Boreal and sub-boreal meadows	Moist or wet eutrophic and mesotrophic grassland	Northern boreal alluvial meadows	Moist or wet oligotrophic grassland	Moist or wet tall-herb and fern fringes and meadows	Temperate thickets and scrub	Common juniper scrub	Temperate shrub heathland	Dry sandy heaths with crowberry	Woodland, forest and other wooded land	Acid siliceous inland cliffs	Boreal calcareous cliff communities	Limestone pavements	Miscellaneous inland habitats with very sparse or no vegetation	Arable land and market gardens
General government	1	0.10	1 316	450	2 321	154	455	2 965	151	208	8	113 178	1	0.24	0.12	19 419	17 984
Non financial corporations	2		1 514	627	2 570	504	565	2 649	346	32	3	476 303		1	1	16 335	27 044
Financial corporations			11	1	2	0.27	2	13	7	0		624				54	92
Households	0.00	0.29	6 434	1 116	6 525	1 260	1 414	7 542	2 555	161	25	680 055	0.14	2	14	19 857	100 487
NPISH			75	10	74	5	19	50	26	0.07	0.27	2 780		0.04		358	345
Rest of the world			235	64	122	113	32	278	249	6	6	15 654			5	585	2 090
State Forest Management Centre	24		1 805	641	13 735	1 636	1 135	1 275	471	154	1	1 049 105		6	42	10 503	1 559
Unknown			132	13	462	19	19	156	32	1		81 392		0	4	1 704	1 142
TOTAL	**27**	**0.40**	**11 523**	**2 922**	**25 811**	**3 693**	**3 641**	**14 929**	**3 837**	**561**	**43**	**2 419 091**	**1**	**10**	**67**	**68 817**	**150 742**

Institutional sector	**Intensive unmixed crops**	**Mixed crops of market gardens and horticulture**	**Arable land with unmixed crops grown by low-intensity agricultural methods**	**Constructed, industrial and other artificial habitats**	**Buildings of cities, towns and villages**	**Urban and suburban industrial and commercial sites still in active use**	**Active opencast mineral extraction sites, including quarries**	**Transport networks and other constructed hard-surfaced areas**	**Airport runways and aprons**	**Highly artificial non-saline standing waters**	**Waste deposits**	**NA**	**Estuaries**	**Pasture woods (with a tree layer overlying pasture)**	**Large parks**	**TOTAL**
General government	52 844	1 330	31 074	4 010	318	1 362	18 825	29 455	3	1 202	15	202	53	694	4 992	**361 356**
Non financial corporations	233 894	1 900	52 226	2 696	278	12 692	694	7 489	456	1 141	30	160	2	1 179	1 553	**888 730**
Financial corporations	165	10	97	42	0.00	41	0.00	23		4		0.47		1	12	**1 377**
Households	392 210	2 888	165 622	60 485	60	2 479	319	14 327	0.06	2 403		357	11	6 791	2 541	**1 603 375**
NPISH	995	41	561	415	37	78	3	545		99		1		37	189	**7 735**
Rest of the world	3 827	63	2 398	1 960	5	81	0.22	412		41		15	8	212	238	**33 954**
State Forest Management Centre	1 304	99	3 431	109	1	42	1 136	7 052		453	0.00	303	63	1 824	39	**1 334 720**
Unknown	3 340	81	1 144	503	24	318	91	1 892	0.02	432		23	0.41	37	141	**115 232**
TOTAL	**688 578**	**6 412**	**256 552**	**70 220**	**722**	**17 093**	**21 068**	**61 195**	**458**	**5 776**	**45**	**1 062**	**138**	**10 774**	**9 706**	**4 346 480**

ANNEX 8. The ownership of the land area of Estonian ecosystem types according to EUNIS habitat classes by activities and sectors, ha

Sector_activity	NACE	NACE Activity	Coastal	Constructed, industrial and other artificial habitats	Grasslands and lands dominated by forbs, mosses or lichens	Habitat complexes	Heathland, scrub and tundra	Inland surface waters	Inland unvegetated or sparsely vegetated habitats	Marine	Mires, bogs and fens	NA	Regularly or recently cultivated agricultural, horticultural and domestic habitats	Woodland, forest and other wooded land	Total
Financial corporations_K	K	Financial and insurance activities	3	110	140	14	20	13	54	21	15	0	363	624	**1 377**
General government_H	H	Transporting and storage	0	31	0	0	0	0	0	0	0	0	0	0	**32**
General government_J	J	Information and communication	0	2	0	0	0	0	4	0	0	0	0	0	**6**
General government_L	L	Real estate activities	2	246	82	96	2	6	73	1	0	0	25	77	**610**
General government_M	M	Professional, scientific and technical activities	0	2	0	2	0	0	0	0	0	0	0	0	**3**
General government_N	N	Administrative and support service activities	0	0	0	0	0	0	1	0	0	0	0	0	**1**
General government_O	O	Public administration and defence; compulsory social security	84	37 658	18 207	1 046	1 806	1 823	12 912	222	12 283	71	91 206	72 557	**249 874**
General government_OTHER			545	16 789	10 556	4 286	1 516	9 464	6 251	2 217	4 910	130	10 765	31 353	**98 781**
General government_P	P	Education	0	244	287	160	8	53	150	0	218	1	1 169	8 915	**11 203**
General government_Q	Q	Human health and social work activities	0	114	61	112	1	2	13	0	1	0	29	61	**396**
General government_R	R	Arts, entertainment and recreation	0	105	32	37	0	5	17	0	1	0	38	215	**450**
Households			495	61 005	78 724	5 990	7 278	4 453	13 166	6 457	10 707	241	375 913	440 133	**1 004 562**
Households_A1	A.01	Crop and animal production, hunting and related service activities	61	11 113	19 502	2 370	1 897	1 547	4 458	1 614	3 137	72	228 065	150 027	**423 863**
Households_A2	A.02	Forestry and logging	12	1 462	3 120	117	199	180	739	163	578	12	17 702	39 538	**63 822**
Households_A3	A.03	Fishing and aquaculture	13	451	639	104	93	48	83	203	111	3	1 473	2 959	**6 183**
Households_B	B	Mining and quarrying	0	8	10	0	0	1	6	0	2	0	90	120	**237**

Sector_activity	NACE	NACE Activity	Coastal	Constructed, industrial and other artificial habitats	Grasslands and lands dominated by forbs, mosses or lichens	Habitat complexes	Heathland, scrub and tundra	Inland surface waters	Inland unvegetated or sparsely vegetated habitats	Marine	Mires, bogs and fens	NA	Regularly or recently cultivated agricultural, horticultural and domestic habitats	Woodland, forest and other wooded land	Total
Households_C	C	Manufacturing	2	455	583	35	41	34	114	55	112	1	2 615	3 733	**7 780**
Households_D	D	Electricity, gas, steam and air conditioning supply	0	10	15	1	1	2	3	0	0	0	29	61	**123**
Households_E	E	Water supply; sewerage; waste management and remediation activities	0	4	4	0	0	0	2	0	8	0	28	16	**63**
Households_F	F	Construction	3	521	665	46	61	33	124	44	54	4	2 591	3 891	**8 037**
Households_G	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	2	737	892	54	88	56	157	37	97	4	4 359	5 308	**11 791**
Households_H	H	Transporting and storage	9	619	737	58	80	41	132	67	100	2	3 862	4 156	**9 862**
Households_I	I	Accommodation and food service activities	1	185	288	45	43	25	61	25	46	2	1 129	2 097	**3 946**
Households_J	J	Information and communication	1	156	280	20	23	12	35	37	33	2	870	1 183	**2 651**
Households_K	K	Financial and insurance activities	0	92	137	8	13	10	16	4	6	1	691	760	**1 737**
Households_L	L	Real estate activities	7	394	564	74	32	40	114	70	97	1	3 759	4 115	**9 265**
Households_M	M	Professional, scientific and technical activities	9	454	702	90	109	48	117	88	115	2	3 825	4 519	**10 078**
Households_N	N	Administrative and support service activities	4	779	1 206	92	100	51	188	85	128	5	4 719	5 954	**13 310**
Households_P	P	Education	0	161	210	11	36	11	33	17	28	1	970	1 242	**2 722**
Households_Q	Q	Human health and social work activities	0	155	199	9	14	24	38	13	24	0	1 078	1 142	**2 697**
Households_R	R	Arts, entertainment and recreation	3	403	549	79	66	31	106	57	95	1	2 150	3 271	**6 811**
Households_S	S	Other services activities	22	909	1 034	136	106	66	182	129	129	3	5 288	5 831	**13 835**
Non financial corporations_A1	A.01	Crop and animal production, hunting and related service activities	8	5 226	7 555	464	778	640	2 700	243	658	38	188 590	34 788	**241 688**
Non financial corporations_A2	A.02	Forestry and logging	18	2 627	16 062	455	973	1 024	4 885	485	4 896	62	54 241	379 419	**465 147**
Non financial corporations_A3	A.03	Fishing and aquaculture	0	183	71	12	6	9	24	0	6	2	132	331	**776**

Sector_activity	NACE	NACE Activity	Coastal	Constructed, industrial and other artificial habitats	Grasslands and lands dominated by forbs, mosses or lichens	Habitat complexes	Heathland, scrub and tundra	Inland surface waters	Inland unvegetated or sparsely vegetated habitats	Marine	Mires, bogs and fens	NA	Regularly or recently cultivated agricultural, horticultural and domestic habitats	Woodland, forest and other wooded land	Total
Non financial corporations_B	B	Mining and quarrying	1	758	315	10	38	17	797	14	264	3	952	1 896	**5 063**
Non financial corporations_C	C	Manufacturing	3	3 192	903	155	53	57	719	22	106	5	2 901	6 250	**14 368**
Non financial corporations_D	D	Electricity, gas, steam and air conditioning supply	23	1 000	1 083	66	53	117	875	34	131	3	784	2 297	**6 468**
Non financial corporations_E	E	Water supply; sewerage; waste management and remediation activities	0	598	346	36	19	136	197	6	15	3	155	331	**1 842**
Non financial corporations_F	F	Construction	10	1 089	913	97	67	50	446	60	71	7	2 241	3 049	**8 101**
Non financial corporations_G	G	Wholesale and retail trade; repair of motor vehicles and motorcycles	4	1 405	977	166	96	55	433	96	213	5	2 679	9 133	**15 261**
Non financial corporations_H	H	Transporting and storage	10	2 091	779	115	107	54	2 138	32	184	3	2 535	2 965	**11 013**
Non financial corporations_I	I	Accommodation and food service activities	9	265	378	154	47	41	97	67	78	1	825	1 140	**3 104**
Non financial corporations_J	J	Information and communication	0	85	179	12	15	6	44	22	3	0	424	455	**1 243**
Non financial corporations_L	L	Real estate activities	75	4 935	5 520	670	537	379	2 151	647	599	24	52 338	26 175	**94 049**
Non financial corporations_M	M	Professional, scientific and technical activities	18	663	769	58	97	53	400	98	59	3	2 804	2 908	**7 930**
Non financial corporations_N	N	Administrative and support service activities	4	338	446	36	59	28	173	40	38	2	1 455	2 089	**4 707**
Non financial corporations_OTHER			4	522	641	135	50	92	152	47	65	0	1 228	2 071	**5 007**
Non financial corporations_P	P	Education	3	37	84	8	9	1	13	1	5	0	167	264	**592**
Non financial corporations_Q	Q	Human health and social work activities	0	47	19	37	0	1	5	1	1	0	31	106	**247**
Non financial corporations_R	R	Arts, entertainment and recreation	6	349	214	41	19	14	67	12	8	1	297	497	**1 524**
Non financial corporations_S	S	Other services activities	0	67	71	9	6	5	21	0	2	0	283	137	**601**
NPISH_L	L	Real estate activities	1	517	45	41	1	12	44	0	1	0	33	89	**784**
NPISH_P	P	Education	0	8	3	5	1	0	3	0	0	0	8	10	**38**

Sector_activity	NACE	NACE Activity	Coastal	Constructed, industrial and other artificial habitats	Grasslands and lands dominated by forbs, mosses or lichens	Habitat complexes	Heathland, scrub and tundra	Inland surface waters	Inland unvegetated or sparsely vegetated habitats	Marine	Mires, bogs and fens	NA	Regularly or recently cultivated agricultural, horticultural and domestic habitats	Woodland, forest and other wooded land	Total
NPISH_Q	Q	Human health and social work activities	0	34	23	18	0	2	6	0	0	0	42	60	**184**
NPISH_R	R	Arts, entertainment and recreation	1	235	134	27	7	5	120	10	1	0	301	364	**1 203**
NPISH_S	S	Other services activities	2	386	655	134	66	39	185	111	131	1	1 558	2 256	**5 525**
Rest of the world			100	2 498	3 805	457	539	185	591	1 197	536	15	8 377	15 654	**33 954**
State Forest Management Centre			1 353	8 791	29 090	1 926	1 902	18 753	10 550	5 507	201 043	303	6 385	1 049 045	**1 334 646**
State Forest Management Centre_A2	A.02	Forestry and logging	0	3	1	0	0	0	1	0	0	0	8	60	**74**
Unknown			65	3 259	2 056	178	189	1 242	1 709	132	19 281	23	5 706	81 392	**115 232**
			2 997	**176 577**	**212 556**	**20 618**	**19 370**	**41 095**	**68 894**	**20 507**	**261 428**	**1 062**	**1 102 284**	**2 419 091**	**4 346 480**

ANNEX 9. Selection of priority ecosystem services

	ECOSYSTEM SERVICE	CICES codes	Service importance for grasslands MeM	KeM	RM	MKM	S.S	H***	Decision (SA and experts)	09.05.2019 decision (stakeholders meeting)	green - feasable method, black - method tbc (to be considered), red- method not applicable METHOD semi-natural and agricultural grasslands
Povisioning services	Fodder	1.1.1.1	1	1	1			A	Y	Y	1. Resource rent approach 2. Rent price approach 3. Benefit transfer (using values from other studies) 4. Expenditure based method 5. Market price approach: agriculture statistics 6. Market price approach: MFA 7. Hybrid approach: combination of resource rent and market price approaches 6. CVM
	Medical herbs	1.1.1.2	2					B	tbc	Y	1. Direct market price 2. Benefit transfer 3. CVM
	Raw material for bioenergy	1.1.1.3	1	1	1	1		A	Y	Y	1. Direct market price
	Food (a) (agriculture, livestock)	1.1.3.1	1	1	1			A	N	Y	*Excluded. We already valuate livestock production through animal feed*
	Food (b) (wild plants, wild animals, fish)	1.1.6.1	2					B	tbc	tbc	1. Direct market price for wild game (trans-ecosystem)
Regulating services	Protection from flooding	2.2.1.3	2	1	1			A	tbc	tbc	*1. Avoided cost method (trans-ecosystem)* *2. Benefit transfer* *3. CVM*
	Pollination	2.2.2.1	1	1				B	Y	tbc	1. Avoided cost method (trans-ecosystem) 2. Benefit transfer 3. CVM
	Habitats for species	2.2.2.3	2	1	1			A	tbc	tbc	*1. Expenditure based method (costs for species and habitat protection)* *2. Expenditure based method (semi-natural grasslands restoration and upkeep costs)* *3. CVM*
	Maintenance of soil fertility	2.2.4.1 & 2.2.4.2	1					B	N	tbc	*1. Replacement cost* *2. CVM*
	Climate regulation (C sequastration, storage)	2.2.6.1	1	1				B	Y	Y	1. PES scheme (CO2 price in EU ETS) 2. CVM
	Natural pest control	2.2.3.1	1	1					tbc	tbc	*n/a*

	ECOSYSTEM SERVICE	CICES codes	Service importance for grasslands MeM	KeM	RM	MKM	S.S	H***	Decision (SA and experts)	09.05.2019 decision (stakeholders meeting)	green - feasable method, black - method tbc (to be considered), red- method not applicable METHOD semi-natural and agricultural grasslands
Cultural services	Tourism, leisure time activities, recreation	3.1.1.1 & 3.1.1.2 & (hunting) 3.1.2.3	2	1	1	1	1	A/B	Y	Y	1. Resource rent method 2. Expenditure based method (cost based approach) (trans-ecosystems) 3. Time use based approach (trans-ecosystem) 4. CVM 5. Travel cost method Hunting: consumer expenditure, benefit transfer
	Environmental education	3.1.2.2	1	1			1	B	Y	Y	1. Expenditure transfer approach (trans-ecosystem) 2. Expenditure based approach (trans-ecosystem) 3. Time use based approach (trans-ecosystem) 4.Travel cost approach 5. CVM
	Aesthetic appreciation and inspiration for culture, art and design	3.1.2.4	2	2			1	C	tbc	tbc	*1. CVM* *2. Expenditure based method (costs to restore semi-natural grasslands)* *3. Direct market price* *4. Hedonic pricing method* *5. Benefit transfer*
	Spiritual experience and sense of place	3.2.1.1	2				1	C	tbc	tbc	*1. Expenditure based method (costs to restore semi-natural grasslands)* *2. CVM*

Explanations:

SA – statistics Estonia

Service importance for grasslands:

MeM – Ministry of Rural Affairs; KeM – ministry of the Environment; RM - Ministry of Finance, MKM – Ministry of Economic Affairs and Communications; S.S- expert opinion on ecosystem cultural services.

H*** - assessment of the need to evaluate the biophysical flows of ecosystem services based on „Ökosüsteemide teenuste kaardistamise ja hindamise tegevuskava“ lisa 6 osa. Editors: Tõnu Oja, Uku Varblane, Anneli Palo, Jaanus Veemaa. Tartu, 2018. https://www.keskkonnaagentuur.ee/sites/default/files/eestis-esmat2htsate-ost-prioriteetsus_tulemuste-tabel.pdf

A- valuation and mapping of the service is necessary in Estonia.; B- mapping of the service is recommended but difficult in practice; C- valuation and mapping of the service may be done but estimated demand is low

ANNEX 10. Questionnaires for service providers

a) Questionnaire for institutions providing only educational services:

Business Register code						
Name of the institution						

Sequence nr.	The name of the nature-education trail or site	Total *	e.g. Taevaskoja	e.g. Vellavere	add ...	Remarks and comments
1.	How big were Your sales revenues in 2018 from these nature-education services´ programs, which included going to the nature? Do not show profit uder the revenues, but only that amount, which was received from providing the nature-education service.					
2.	Please evaluate approximately, which were Your other incomings (for example subsidies) for these nature-education services´ programs, which included going to the nature, in 2018?					
3.a.	Number (approximate) of students (kindergarten children, school- and university students, adults) participated in your nature-education programs for nature-education purposes, in 2018.					
3.b	Average visit excursion duration in hours (time spent from "door to door").					
3.c	Estimated average time share spent in the ecosystem itself from the programs which include going to the nature (% of the given nature-education in a nature object itself), in 2018.					
3.d	Did you use State Forest Management Centre´s infrastructure?					

Additional remarks and comments	

* If you can´t provide information about visited nature-education trails or sites separately - for questions 3a-3d - we´d be grateful, if You can provide requested information in consolidated numbers about nature-education trails or sites in total (column "C") and list of destinations as a free text (column "G" - "Remarks and comments").

2) Questionnaire for institutions providing only educational services (public funded educational institutions):

Business Register code						
Name of the institution						
Sequence nr.	The name of the nature-study trail or site	Total *	e.g. Taevaskoja	e.g. Vellavere	add ...	Remarks and comments
1.	Please evaluate approximately, which were Your incomings (for example subsidies) for these nature-education services´ programs, which included going to the nature, in 2018?					
2.a	Number (approximate) of students (kindergarten children, school- and university students, adults) participated in your nature-education programs for nature-education purposes, in 2018.					
2.b	Average visit excursion duration in hours (time spent from "door to door").					
2.c	Estimated average time share spent in the ecosystem itself from the programs which include going to the nature (% of the given nature-education in a nature object itself), in 2018.					
2.d	Did you use State Forest Management Centre´s infrastructure?					
Additional remarks and comments						
	* If you can´t provide information about visited nature-education trails or sites separately - for questions 2.a-2.d - we´d be grateful, if You can provide requested information in consolidated numbers about nature-education trails or sites in total (column "C") and list of destinations as a free text (column "G" - "Remarks and comments").					

3) Questionnaire for institutions owning and managing nature education trail and/or site in addition:

Business Register code					
Name of the institution					
Name of the managed and/or visited nature-study service providing learning center/nature center, nature-study trail or site.	TOTAL *	Name 1	Name 2	Add...	Remarks and comments
Which were Your spendings for providing nature-education (which were connected to introducing Estonian nature) in the study- or nature center administered by You, but also in providing education on the nature trail or place on-site, in 2018?					
including (if it is possible to distinguish):					
...visit-center					
...trails					
...signs (direction signs, marks, labels)					
...stands, displays					
...study-, field trips					
...personnel costs					
...other information materials					
...access roads					
...other					
Number (approximate) of students (kindergarten children, school- and university students, adults) participated in your nature-education programs for nature-education purposes, in 2018. Please provide information also about these programs, which are conducted in other places than in the nature-trail or site which You administrate.					
Average visit excursion duration in hours (time spent from "door to door").					
Estimated average time share spent in the ecosystem itself from the programs which include going to the nature (% of the given nature-education in a nature object itself), in 2018.					
Did you use State Forest Management Centre´s infrastructure?					
Comments					
* If you can´t provide information about nature-education trails or sites which You administrate or other visited nature-education trails or sites separately, we´d be grateful, if You can provide requested information in consolidated numbers about nature-education trails or sites in total (column "B", Total) and list of destinations as a free text (column "F" - "Remarks and comments").					

ANNEX 11. The supply and use of nature education service (thousand €), 2018

	Ecosystems	Corporations						General government			NPISH	Final consumption of households	Total
		Forestry (A.02)	Land transport (H.49)	Real estate activities (L.68)	Scientific and technical activities, (M.74_75)	Education (P.85)	Sports and recreation activities (R.93)	Public administration (O.84)	Education (P.85)	Creative, entertainment, culture (R.90_91)	Activities of membership organizations (S.94)		
Expenditure transfer approach													
Supply													**5 120**
Ecosystem service - nature education	5 120												5 120
Nature education													
Use													**5 120**
Ecosystem service - nature education													
Nature education												5 120	5 120
Value added (supply-use)	**5 120**												**5 120**
Expenditure based method													
Supply													**1 586**
Ecosystem service - nature education	268												268
Nature education		650		0	0	4	9	35	67	414	128		1 309
Use													**1 586**
Ecosystem service - nature education		211		0	0	0	9	3	7	41	13		268
Nature education												1 309	1 309
Value added (supply-use)	**268**	**438**		**0**	**0**	**4**	**8**	**31**	**61**	**373**	**115**		**1 309**
Travel cost based approach													
Supply													**2 023**
Ecosystem service - nature education	304												304
Nature education			1 719										1 719
Use													**2 023**
Ecosystem service - nature education			304										304
Nature education												1 719	1 719
Value added (supply-use)	**304**		**1 415**										**1 719**
Willingness to pay method													
Supply													**1 271**
Ecosystem service - nature education	1 271												1 271
Nature education													
Use													**1 271**
Ecosystem service - nature education												1 271	1 271
Nature education													
Value added (supply-use)	**1 271**												**1 271**